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ABSTRACT

The implementation of the Science - A Process Approach in more than 70 school districts (about 9,000 elementary school classrooms) in the state of Texas is described in this report. The following objectives were established for the implementation project: demonstrate a curriculum innovation in science; demonstrate an inservice education program that contains a model for inservice activity in other subject areas; conduct leadership training and coordinate the subsequent activities for staff of school districts or regional service center in the state; and develop alternative approaches to inservice education based on insights gained in the evaluation activities. The appendices contain two related conference reports. The first conference report describes the 1968 Leadership Conference for individuals with responsibility in continuing teacher education programs in the implementation of new curriculum in science in the elementary school. The report "5th Science Conference for Teachers Using A Process Approach to Elementary School Science" presents the rationale for the process approach. This work was prepared under an ESEA Title III contract. (PR)

ED 059867

A RESEARCH-DEVELOPMENT ACTIVITY

SCIENCE EDUCATION CENTER

THE UNIVERSITY OF TEXAS

IMPLEMENTING CURRICULUM CHANGE

IN ELEMENTARY SCHOOL SCIENCE

A
FINAL REPORT
PROJECT NO. 67-3669-0
GRANT NO. OEG 3-7-703699-5250

Curriculum Dissemination Center
June 1969

U. S. Department of
Health, Education, and Welfare

Office of Education
Bureau of Research

OE 4381 (11-66)

DEPARTMENT OF HEALTH, EDUCATION AND WELFARE
OFFICE OF EDUCATION
WASHINGTON D.C. 20202

BUDGET BUREAU NO. 51-R606
APPROVAL EXPIRES 6/30/69

ESEA TITLE III STATISTICAL DATA

Elementary and Secondary Education Act of 1965 (P.L. 89-10)

THIS SPACE FOR U.S.O.E. USE ONLY	PROJECT NUMBER	STATE CODE	COUNTY CODE	REGION CODE	STATE ALLOTMENT

SECTION A - PROJECT INFORMATION

1. REASON FOR SUBMISSION OF THIS FORM *(Check one)*
   - A [ ] INITIAL APPLICATION FOR TITLE III GRANT OR RESUBMISSION
   - B [ ] APPLICATION FOR CONTINUATION GRANT
   - C [X] END OF BUDGET PERIOD REPORT

2. IN ALL CASES EXCEPT INITIAL APPLICATION, GIVE OE ASSIGNED PROJECT NUMBER
   OEG-3-7-703669-5250

3. MAJOR DESCRIPTION OF PROJECT: *(Check one only)*
   - A [ ] INNOVATIVE
   - B [ ] EXEMPLARY
   - C [ ] ADAPTIVE

4. TYPE(S) OF ACTIVITY *(Check one or more)*
   - A [ ] PLANNING OF PROGRAM
   - B [ ] PLANNING OF CONSTRUCTION
   - C [ ] CONDUCTING PILOT ACTIVITIES
   - D [ ] OPERATION OF PROGRAM
   - E [ ] CONSTRUCTING
   - F [ ] REMODELING

5. PROJECT TITLE *(5 Words or Less)*

6. BRIEFLY SUMMARIZE THE PURPOSE OF THE PROPOSED PROJECT AND GIVE THE ITEM NUMBER OF THE AREA OF MAJOR EMPHASIS AS LISTED IN SEC. 303, P.L. 89-10. *(See instructions)*

ITEM NUMBER ______

7. NAME OF APPLICANT *(Local Education Agency)*

8. ADDRESS *(Number, Street, City, State, Zip Code)*

9. NAME OF COUNTY

10. CONGRESSIONAL DISTRICT

11. NAME OF PROJECT DIRECTOR

12. ADDRESS *(Number, Street, City, State, Zip Code)*

PHONE NUMBER

AREA CODE

13. NAME OF PERSON AUTHORIZED TO RECEIVE GRANT *(Please type)*
    Irby B. Carruth

14. ADDRESS *(Number, Street, City, State, Zip Code)*
    6100 North Guadalupe Street
    Austin, Texas 78752

PHONE NUMBER 452-9331

AREA CODE 512

15. POSITION OR TITLE
    Superintendent of Schools

SIGNATURE OF PERSON AUTHORIZED TO RECEIVE GRANT

Irby B. Carruth

DATE SUBMITTED
October 6, 1969

SECTION A – Continued

16. LIST THE NUMBER OF EACH CONGRESSIONAL DISTRICT SERVED	17A. TOTAL NUMBER OF COUNTIES SERVED	49	18. LATEST AVERAGE PER PUPIL ADA EXPENDITURE OF LOCAL EDUCATION AGENCIES SERVED
6, 10, 14, 17, 18, 20	B. TOTAL NUMBER OF LEA'S SERVED	6	$ 339.76
	C. TOTAL ESTIMATED POPULATION IN GEOGRAPHIC AREA SERVED	357,572	

SECTION B – TITLE III BUDGET SUMMARY FOR PROJECT (Include amount from item 2c below)

1.		PREVIOUS OE GRANT NUMBER	BEGINNING DATE (Month, Year)	ENDING DATE (Month, Year)	FUNDS REQUESTED
A.	Initial Application or Resubmission				$
B.	Application for First Continuation Grant				$
C.	Application for Second Continuation Grant				$
D.	Total Title III Funds				$
E.	End of Budget Period Report	OEG3-7-703669-5250	7-1-68	6-30-69	

2. *Complete the following items only if this project includes construction, acquisition, remodeling, or leasing of facilities for which Title III funds are requested. Leave blank if not appropriate.*

A *Type of function (Check applicable boxes)*

1 [ ] REMODELING OF FACILITIES   2 [X] LEASING OF FACILITIES   3 [ ] ACQUISITION OF FACILITIES

4 [ ] CONSTRUCTION OF FACILITIES   5 [ ] ACQUISITION OF BUILT-IN EQUIPMENT

B	1. TOTAL SQUARE FEET IN THE PROPOSED FACILITY	2. TOTAL SQUARE FEET IN THE FACILITY TO BE USED FOR TITLE III PROGRAMS	C	AMOUNT OF TITLE III FUNDS REQUESTED FOR FACILITY
		1000 sq.ft. and 9 parking spaces		3900.00 requested $ 3325.00 disbursed

SECTION C – SCHOOL ENROLLMENT, PROJECT PARTICIPATION DATA AND STAFF MEMBERS ENGAGED

1.			PRE-KINDERGARTEN	KINDERGARTEN	GRADES 1-6	GRADES 7-12	ADULT	OTHER	TOTALS	STAFF MEMBERS ENGAGED IN IN-SERVICE TRAINING FOR PROJECT
A	School Enrollment in Geographic Area Served	(1) Public			306,469					
		(2) Non-public			38,990					
B	Persons Served by Project	(1) Public			196,174					2140
		(2) Non-public		1190	22,670					100
		(3) Not Enrolled								
C	Additional Persons Needing Service	(1) Public			110,295					3532
		(2) Non-public			15,130					518
		(3) Not Enrolled								

2. TOTAL NUMBER OF PARTICIPANTS BY RACE *(Applicable to figures given in item 1B above)*	WHITE	NEGRO	AMERICAN INDIAN	OTHER NON-WHITE	TOTAL
	149,625	24,204	-	46,205	220,034

SECTION E - NUMBER OF PERSONS SERVED OR TO BE SERVED AND ESTIMATED COST DISTRIBUTION

	MAJOR PROGRAM OR SERVICES	TOTAL NUMBER SERVED OR TO BE SERVED						NONPUBLIC SCHOOL PUPILS INCLUDED (7)	ESTIMATED COST (8)
		PRE-K (1)	K (2)	1-6 (3)	7-12 (4)	ADULT (5)	OTHER (6)		
1.	EVALUATIVE PROGRAMS								
A	Deficiency Survey (Area Needs)								
B	Curriculum Requirements Study (Including Planning for Future Need)								
C	Resource Availability and Utilization Studies								
2.	INSTRUCTION AND/OR ENRICHMENT								
A	Arts (Music, Theater, Graphics, Etc.)								
B	Foreign Languages								
C	Language Arts (English Improvement)								
D	Remedial Reading								
E	Mathematics								
F	Science		400	115,200		3840		2920	114,186.55
G	Social Studies/Humanities								
H	Physical Fitness/Recreation								
I	Vocational/Industrial Arts								
J	Special-Physically Handicapped								
K	Special-Mentally Retarded								
L	Special-Disturbed (Incl. Delinquent)								
M	Special-Dropout								
N	Special-Minority Groups								
3.	INSTRUCTION ADDENDA								
A	Educational TV/Radio								
B	Audio-Visual Aids								
C	Demonstration/Learning Centers								
D	Library Facilities								
E	Material nd/or Service Centers					12	48		35,770.16
F	Data Processing								
4.	PERSONAL SERVICES								
A	Medical/Dental								
B	Social/Psychological								
5.	OTHER								5,924.66

SECTION C - continued

3. RURAL/URBAN DISTRIBUTION OF PARTICIPANTS SERVED OR TO BE SERVED BY PROJECT

PARTICIPANTS	RURAL		METROPOLITAN AREA		
	FARM	NON-FARM	CENTRAL-CITY	NON-CENTRAL CITY	OTHER URBAN
PERCENT OF TOTAL NUMBER SERVED	1.2	7.5	85.0	4.3	2.0

SECTION D - PERSONNEL FOR ADMINISTRATION AND IMPLEMENTATION OF PROJECT

1. PERSONNEL PAID BY TITLE III FUNDS

TYPE OF PAID PERSONNEL	REGULAR STAFF ASSIGNED TO PROJECT			NEW STAFF HIRED FOR PROJECT		
	FULL-TIME 1	PART-TIME 2	FULL-TIME EQUIVALENT 3	FULL-TIME 4	PART-TIME 5	FULL-TIME EQUIVALENT 6
A. ADMINISTRATION/ SUPERVISION	1	1	1.50			
B. TEACHER:						
(1) PRE-KINDERGARTEN						
(2) KINDERGARTEN						
(3) GRADES 1-6	3		3	7		7
(4) GRADES 7-12						
(5) OTHER						
C. PUPIL PERSONNEL SERVICES						
D. OTHER PROFESSIONAL				1		1
E. ALL NON-PROFSSIONAL	2	2	3			
F. FOR ALL CONSULTANTS PAID BY TITLE III FUNDS	(1.) TOTAL NUMBER RETAINED 12			(2.) TOTAL CALENDAR DAYS RETAINED 44		

2. PERSONNEL NOT PAID BY TITLE III FUNDS

TYPE OF UNPAID PERSONNEL	REGULAR STAFF ASSIGNED TO PROJECT			NEW STAFF HIRED FOR PROJECT		
	FULL-TIME 1	PART-TIME 2	FULL-TIME EQUIVALENT 3	FULL-TIME 4	PART-TIME 5	FULL-TIME EQUIVALENT 6
A. ADMINISTRATION/ SUPERVISION		1	1/3			
B. TEACHER:						
(1) PRE-KINDERGARTEN						
(2) KINDERGARTEN						
(3) GRADES 1 TO 6		12	3			
(4) GRADES 7-12						
(5) OTHER						
C. PUPIL PERSONNEL SERVICES						
D. OTHER PROFESSIONAL		4	2			
E. ALL NON-PROFESSIONAL						
F. FOR ALL CONSULTANTS NOT PAID BY TITLE III FUNDS	(1.) TOTAL NUMBER RETAINED 4			(2.) TOTAL CALENDAR DAYS RETAINED 16		

Table of Contents

I. Introduction

Changing the learning experiences of students has been the ultimate goal of curriculum innovations in mathematics, science and, more recently, social studies and linguistics. Such curriculum innovations represent the combined talents of teams of academicians, classroom teachers and learning theorists. But existence of these curricula does not mean that students' learning experiences actually have been changed. Spanning the development of a curriculum from innovation to institutionalization represents the challenge of our day. This challenge can be met only by the development of an adequate base of manpower. People plus programs equal change, whereas programs without people remain on the supervisor's office shelf!

Change in the students' learning experience can be facilitated through the way those experiences are structured. The structure of the learning experience includes both the curriculum and the teacher who uses that curriculum. The nature of the newer curriculum innovations are such that their effective use requires an understanding of both the subject and the method that was built into the design of the program. To use the innovation effectively, most teachers must modify considerably previous teaching procedures. Teachers can no longer "teach as they have been taught." They can no longer simply have students ccpy notes presented largely from the teacher's old college notebooks!

The curriculum innovation implemented in this study, Science - A Process Approach, has been developed by the Commission on Science

Education of the American Association for the Advancement of Science with support from the National Science Foundation. Its use in more than 9,000 classrooms in the State of Texas illustrates the extent to which both the curriculum and its related inservice teacher education program have been piloted, field tested and disseminated within the state. This achievement is the product of a series of activities dating from 1963.

In 1963 the curriculum innovation itself was field tested in Austin, Texas, as one of ten tryout centers in the nation for the classroom use of materials developed by AAAS. The teachers in Austin came from four elementary schools representing a cross section of the public school population in the city. The teachers' response to the new science program was enthusiastic. Austin Public School officials requested that the program be expanded within the school system. Appropriate permissions were secured from the Commission on Science Education of AAAS for this expansion.

During the summer preceding the 1964-65 school year, AAAS directed the revision of the kindergarten-to-third-grade materials of Science - A Process Approach and prepared new materials for grades four and five. During that same summer, in Austin, a teacher education program was developed by the ten teachers in the Austin tryout center as part of the Science Inservice Project. Seventy additional teachers in Austin participated in the first year of the Science Inservice Project. This Project was sponsored jointly by the Science Education Center of The University of Texas, the Austin Independent School District, and the U.S. Office of Education through a cooperative research grant.

During the 1965-66 school year, two more groups of teachers were added to the Science Inservice Project. One was a private parochial school and the other was a group of teachers who were participants in the language research studies project in San Antonio, Texas, another U.S. Office of Education cooperative research grant.

During the summer of 1965, as AAAS revised the K-5 materials and added materials for grade six, the teacher education program of the Science Inservice Project was used in six new pilot centers in Texas. Evaluation and follow-up was planned through the resources of the Research and Development Center on Teacher Education at The University of Texas and local school districts. Analysis of these studies was completed by the staff of the Science Inservice Project.

During the 1965-66 school year, requests were received from 19 Texas school districts for pilot centers. These requests came through the Texas Education Agency. Because the staff of the Science Education Center was obviously inadequate to handle these requests, a mechanism for delivering assistance to those school districts was sought. The planning of the Curriculum Demonstration Center began as a solution. These planning activities involved teachers, supervisory personnel, school administrator's staff and state education department staff as well as staff of The University of Texas.

Between 1966 and 1969 the Curriculum Demonstration Center has been a vehicle through which more than 70 school districts have piloted the curriculum and the means that introduced more than 5,000 teachers to new experiences in science for their children.

As part of the pilot and field test activity of the project, evaluation studies have been completed which indicate the trends listed below:

A. When student achievement is considered, results indicate that:

1. Students in experimental programs do as well on "traditional" science tests as their counterparts in traditional classrooms.

2. Students' attitudes towards their teacher are intensified more in the new program, indicating a much more powerful student-teacher interaction.

3. Students' attitude towards science in school improves. It is characterized as being good and doing something.

4. Boys and girls perform equally well in science.

5. Grade level seems to be an important factor in achievement. Fourth grade is highest and the sixth grade is lowest. This would indicate that one must initiate discovery, that is self-responsible learning, early in the school life. By the time a child has reached the sixth grade, it may be too late to learn how to learn.

6. When a variety of components of cognitive activity are considered, such as intelligence, past experience and creativity, a trend toward a dramatic shift in students' performance appears to occur after two years in the program. This would indicate that school districts ought to plan pilot activities to extend more than a single year.

7. Analysis of students' contrasting ethnic backgrounds indicate that they seem to feel the same trends of improvement. This would indicate that "disadvantaged" students can and do achieve success with appropriate instructional experience. It also suggests that "advantaged" students need a type of instructional experience that they may not now be receiving.

8. Achievement level of five and six-year-old children of obviously contrasting ethnic backgrounds is equally high on non-verbal tasks. On verbal tasks achievement

appears to be very much related to the ethnic background of the child.

9. Student achievement is not related to community, grade level, or program; but the most significant factor on achievement is the teacher. This result is observable in several studies and emphasizes the need for well-trained teachers as well as adequately designed programs.

B. Teachers most likely to succeed with an innovation in science appear to be those who have had:

1. Few courses in science.

2. More than three years teaching experience (but there does not appear to be an upper limit).

3. A principal who supports the teacher's activity.

4. A school administration which supports the use of the innovation.

5. A positive attitude toward the program (results of several evaluations indicate that a successful inservice experience serves to enhance the teacher's attitude).

6. A working knowledge of the curriculum innovation (which is also directly related to the staff development program).

7. Teaching assignments in the primary grades (teachers at the intermediate grades seem to experience greater difficulty with the non-direct discovery approach to instruction).

C. When the sequence of staff development programs has been studied, it is evident that where least time pattern produces the greatest change in the teacher's background knowledge, their attitude and classroom behavior, preschool workshops are ranked next with college institutes during the school year being the least effective.

In summary, conditions for success in the implementation of a curriculum change in science are: (1) teachers educated in the use of the curriculum in a program that offers both knowledge of the change and opportunity for guided practice in working with small and large numbers of children; (2) an opportunity for the teacher to use the curriculum in a classroom with confidence in a school district commitment; (3) a teacher who is willing to use the program; and (4) a principal who both exerts a direct influence on the instruction in his building and who perceives himself as responsible for this area of the school activity.

A number of research studies conducted in connection both with this project and with the implementation of the curriculum innovation in the State of Texas are reported in a separate publication: "Research and Curriculum Development in Science Education." No. 2, Elementary School Science Implementation, The University of Texas publication.

The effectiveness of a curriculum innovation is directly dependent upon the preparation of the teacher. Where, how and when a teacher is to secure that preparation is a most important series of questions. Teacher change is dependent upon at least the degree and amount of administrative support for that change, and also upon the opportunity for teachers to experience and practice the "new look" in their classroom roles. The opportunities for experience and practice come as part of a teacher education program which is directed by competent leaders of staff. Initially, this leadership staff may come from outside the school system. But if change is to become a part of the system, the source for change must eventually become a part of the home base.

To initiate change from the home base, one approach has been to structure awareness conferences in which the decision-maker has the opportunity to secure information about the curriculum innovation. A second step in this implementation model is the demonstration setting, in which the decision-maker can examine further the changed classroom procedures and question users. After taking advantage of these two sources of information, the decision-maker can then choose whether or not to adopt the program of change.

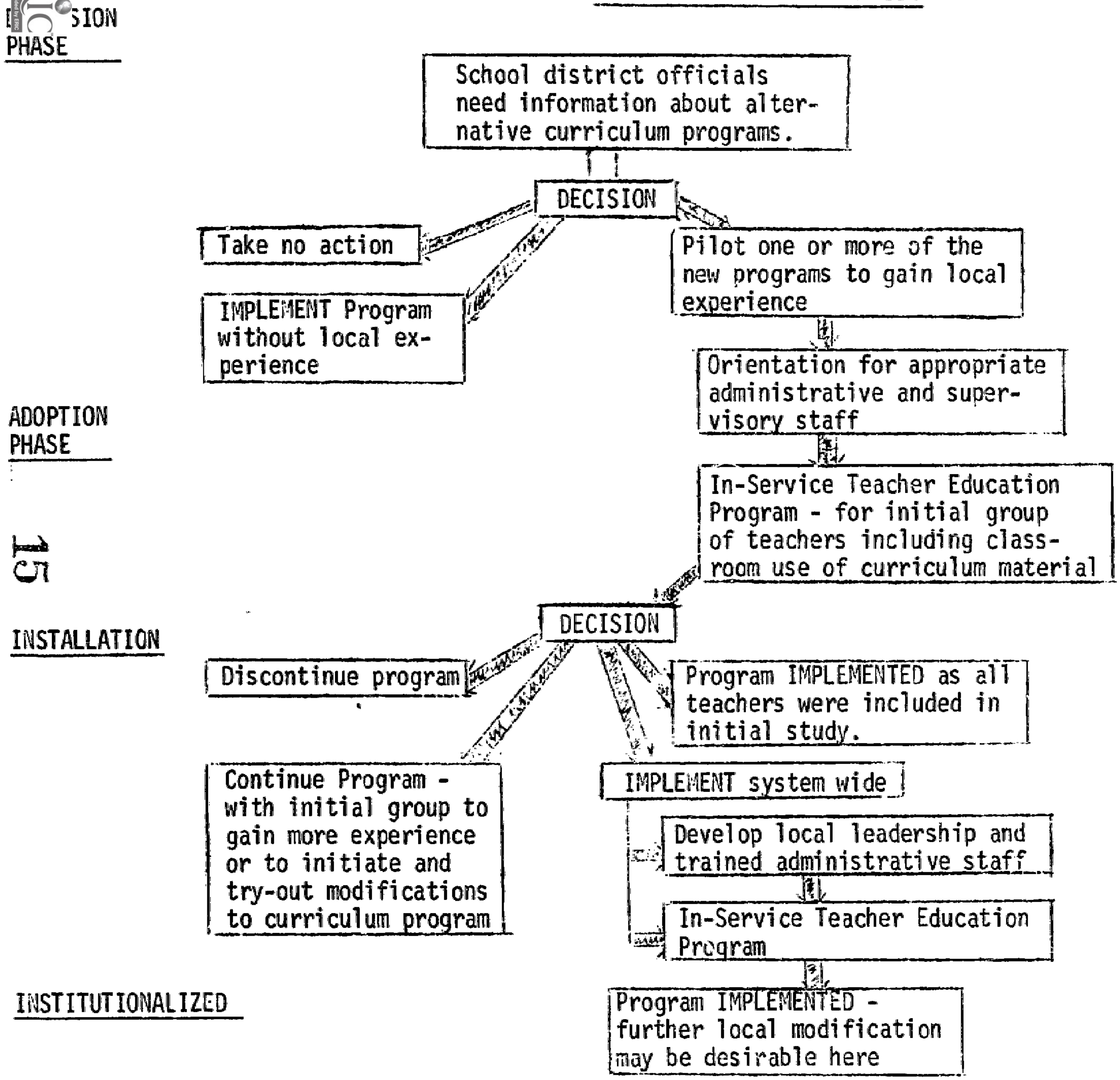
If adoption is initiated through the decision-maker, there appears to be a third relevant step: to pilot test the innovation in the local situation. Here the local experience will provide insight as to the adequacy of the teacher education program, the appropriateness of the curriculum materials for students and the capability of the local school system for supporting the logistics required by the innovation. This step usually requires the assistance of outside resources to direct and guide the pilot use of the curriculum innovation.

The next step in the installation of a program within a system is the development of local leadership for the implementation of the curriculum innovation and the development and adaptation of the curriculum innovation itself to meet local conditions. Depending on the size of the system and the amount of resources, the installation process may take from two to four years.

The follow-up phase in implementing a program, its institutionalization, is one in which the means are provided for continued training of new members of the teaching and administrative staff and continued effective utilization of the curriculum innovation is assured.

Figure 1 incorporates the three phases of implementation with their relevant decision points. In this figure the nomenclature used is: S = student, T_1 = teacher, T_2 = local leadership staff, T_3 = regional resource staff or staff of the local college.

A MODEL FOR IMPLEMENTATION



Staff Development Function

1. T_3 provides information.

2. T_3 conduct teacher education program for administrators.

3. T_3 conduct in-service teacher education program for pilot teachers. T_1

4. T_3 serve as consultant during the school year to T_1.

5. T_3 assist school district in planning next steps.

6. T_3 conduct Leadership Teacher Program for T_2.

7. T_3 coordinates teacher education program where T_2's work with T_1's in a school district.

Figure 1

II. Objectives of the Operational Grant

Under the terms of the operational grant for the Curriculum Dissemination Center the following objectives were established as guides for action:

1. Demonstrate a curriculum innovation in science;

2. Demonstrate an inservice education program that contains a model for inservice activity in other subject areas;

3. Conduct leadership training and coordinate the subsequent activities for staff of school districts or regional service centers in the state;

4. Develop alternative approaches to inservice education based on insights gained in the evaluation activities.

For convenience of presentation, the activities related to each of these objectives are separately prescribed.

Objective 1: To demonstrate a curriculum innovation in science.

Plan

To accomplish this objective, the initial plan included a series of demonstration centers as locations in which interested school personnel might both observe and discussion new curriculum innovations. With the organization of the Regional Service Centers, the plan was modified to incorporate this function into the operation of the service center. The Curriculum Demonstration Center would then assist Regional Service centers to develop demonstration schools within their regions in which teachers of at least four grade levels would be using the curriculum innovation.

Progress

During the two-year period, demonstration school settings have been generated in 12 of the Regional Service Centers (Regions I, III, VII, VIII, X, XII, XIII, XIV, XV, XVII, XIX, XX). The success of this plan of more local information for decision-makers is indicated by the number of regions which will continue the activity even after the funding of the present project has ceased. Eleven of the 12 regions (Regions I, III, VII, VIII, X, XII, XIII, XIV, XV, XVII, and XX) have confirmed that they plan to continue their work which was initiated in cooperation with this project.

Objective 2: Demonstrate an inservice education program that can serve as a model for inservice activity in other subject areas.

Plan

To implement a curriculum which emphasizes discovery by the student, an accompanying staff development program is necessary, because teachers often are not accustomed to conducting classes in the manner in which the curriculum materials are organized. The staff development program was to be directed toward a new approach in teaching elementary school science. Evidence exists, however, that indicates a transfer of teaching strategies developed within this staff development program from science toward other curriculum areas (mathematics, social studies and language arts). The innovation in the staff development program was a constant focus on teaching children. More than half of the staff development program is built around observing and interpreting the student learning encounters, leaving the gate open for an overflow into other subject areas.

Progress

Flexibility in the design of the staff development program is the keystone. The pilot program was structured on a released-time basis for participating teachers. Eighty-six teachers were involved in the pilot test. They participated in 11 half-day sessions during the school year. Five of these sessions met once a week for five consecutive weeks. After completing the third session, teachers began to use the instructional materials in their own classrooms. Sessions 6-11 were held approximately one month apart. These provided for continual development of science background of the teacher and an opportunity for teachers to seek help and provide feedback from their classroom experiences. The number of teachers in each grade level inservice session was approximately 10. Thus, all activity in a staff development meeting was directly related to each teacher's primary interest--what was expected of her in the classroom.

During the staff development sessions, teachers alternately observed classroom demonstrations and analyzed these in follow-up discussions. In addition, teachers actively participated in the sessions designed to develop an understanding of the meaning of the curriculum's structure. These sessions enabled an understanding of the process approach to teaching and provided background information in the science content which was being used as a vehicle for communicating the program structure. The teachers also were visited in their classrooms and offered follow-up assistance to facilitate the implementation of the program in the classroom. Based on the pilot experience and work of

91 school districts, a series of alternative schedules for staff development have been postulated and tested. As an illustration of the flexibility, the following plans have been used:

A. Summer workshops for volunteer teachers, three-weeks long; morning-only sessions with monthly after-school follow-through meetings.

B. Summer workshops wi volunteer teachers, three-week sessions; full day ..th no follow-through schedule.

C. Summer workshops volunteers or stipends for full-day sessions of one week with six follow-through meetings scheduled during the school year.

D. Summer workshop with volunteers or stipends for five half-day sessions with or without follow-through schedules.

E. Summer workshops for two days with six full days of released time schedule during the school year.

F. Summer workshop of six weeks, full day with stipends and necessary follow-through scheduled during the school year.

G. Released time during the school year of 11 half-days.

H. Released time during the school year with 8 half-days.

I. Released time during the school year with 7 full days.

J. Released time during the school year with 5 full days.

K. After-school staff development program of 31 hour sessions.

L. After-school program with 8 sessions.

M. An academic institute of 8 evenings of two-hour sessions each week.

As has been previously noted, experience gained in the implementation of one curriculum innovation, Science - A Process Approach, has indicated that the staff development of classroom teachers is a crucial step in the process of implementation. Through the combined activitie of the Science Inservice Project and the Curriculum Demonstration Center, research evidence indicates that innovative curricula such as Science - A Process Approach requires more than well-prepared teachers manuals and student equipment. Effective translation of these materials into classroom use follows only after additional training of the teacher. To this end, the inservice program has been written by teachers and revised as they have experienced needs in the classroom use of the innovation. This inservice program has been designed to meet these two needs:

1. Inadequate academic background to use the curriculum innovation, hence the need for a program to increase teacher competence in the subject area.

2. Inadequate teaching strategies to foster inquiry and individual responsibility in learning, hence the need for a program to increase teacher competence in the teaching strategies for inquiry.

The key means by which specific needs have been identified has been the use the teachers as a source of information about both problems and their relevant solutions. Following the activities of the 1964-65 school year, the staff development program was revised, utilizing the suggestions of teachers regarding the activities they found most helpful. These suggestions resulted from asking teachers what they wished would be included in the staff development program if they had the opportunity to roll the calendar back and start the year over again. The teachers identified those specific kinds of experiences which they felt would be most helpful in giving them the orientation and preparation for the use of the curriculum materials. Their suggestions include "less talk and more action" and demonstrations with children with analyses following these demonstrations to identify why specific teaching strategies were or were not used.

After the 1965-66 school year, teachers were again given opportunities to suggest additions or deletions from the staff development program. Specific suggestions included more emphasis on planning activities for teachers and science background sessions which are presented in a manner similar to the way the teachers are expected to teach.

The focus of the problem of implementing an innovation becomes the identification of strategy or organization for guiding the learning experiences for children. Logically, a learning experience for teachers should begin with illustrations of teachers teaching. This would continue with classroom practice and culminate with the analysis of experience. The reality of the educational encounter thus becomes the primary means by which teachers can be confronted with the need for a new knowledge about teaching and guided in their development and the understanding of an innovation.

Three assumptions comprise the rationale for this approach to the staff development of a teacher. If the activities arising from one of these assumptions are omitted, the objective of the staff development program may well be far less than satisfactory.

Quite logically a teacher cannot be interested in change if she has no knowledge of it or its potential; therefore:

> Assumption 1 is that knowledge of the innovation precedes and is essential to its implementation.

However, even if one has this knowledge, no action may result because there is no commitment to change. Many brilliant speeches have inspired little more than praise when action was needed. A key factor may be that there was no need for action in that there was no commitment on the

part of the teacher to any change in the classroom. Thus

Assumption 2 is that commitment to use the innovative curriculum is essential to its implementation.

Even with knowledge of change and a commitment to its implementation, results may be far from satisfactory for both the teacher and the student. What the printed page communicates varies in direct proportion to the relevant past experience of the reader. Therefore,

Assumption 3 is that guidance in the use of the innovation is essential to its implementation.

To be communicated adequately, such experiences must draw upon the reality of the classroom to provide a rationale for real change. This approach to staff development has as its primary focus the Educational Encounter. (See Appendix A for a more detailed description of the Educational Encounter.)

Objective 3: Conduct the leadership training and coordinate the follow-through activities for staff of school districts or Regional Service Centers in the state.

Plan

The initial information service and staff development of teachers in a district was to be conducted by outside resource staff of the Regional Service Centers (T_3). During the year of pilot use, local lead teachers (T_2) would be identified as scheduled for participation in a summer leadership training conference. This T_2 could then assume major responsibility for the inservice program at the local district level under the coordination of the T_3 and the Regional Service Center.

Progress

During the summer of 1967 staff members of Regional Service Centers (Regions XIII, XIV, XV, XVI, XVII, and XX) participated in the first leadership conference. One of the activities of this conference was for these five individuals to design inservice sessions. These sessions were then tried out in an inservice workshop and revised as needed. A feedback session was held after each one of the inservice sessions with the director and the staff. At the completion of the workshop, the T_3s returned to their respective regions to conduct workshops within that region. Periodically, they returned to Austin for feedback on specific problems.

In addition to scheduling and conducting inservice activities, they were responsible for conducting awareness conferences with other school districts in their regions and in working with individual school districts on the problem of procurement and distribution of equipment.

A second leadership conference was held during the summer of 1968 at which time 41 T_3s and T_2s participated in a series of activities designed to prepare them to serve as effective inservice instructors (see Appendix B for a full report of this conference). At the second conference nine new T_3s from Regions I, III, VII, VIII, X, and XIX were added to the program. Twenty-eight local lead teachers (T_2) were also involved from Regions I, VII, XII, XIII, XIV, XVI, XVII, and XX. Thus as a model for implementing change in science, the sequence described in Figure 1 appears to be a successful approach. Its applications to other subject areas has not been systematically studied. Similar approaches are being utilized in new programs in social studies and, to a limited extent, in bilingual educational programs. The success of this approach is in part reflected by the commitment of 14 of the Regional Service Centers to continue to serve as an agency for piloting programs in their regions and in coordinating the programs in districts when there is a commitment for complete implementation (Regions I, III, IV, V, VI, VII, VIII, IX, X, XII, XIII, XIV, XV, and XVII have indicated such a commitment.) Through this plan more than 3,000 teachers are scheduled to participate in summer and school year staff development programs during 1969-70.

Objective 4: Develop alternative approaches to inservice education based on insights gained in the evaluation activities.

Plan

Based on the experience with staff development programs and feedback of teachers after one or two-years' experience in the use of these programs, a modified staff development program was to be engineered to include: (a) experience for the task by the teacher to gain self-confidence and competence; (b) analysis of the task and design of instruction -- the pre-active phase of teaching, including the specification of subtasks, performance objectives and alternative student involvement activities; (c) analysis of teaching behaviors and the interactive phase of teaching, including focus on teacher and student verbal and non-verbal behavior; (d) generalization of the task to other subject areas, including analysis of the skills in science as related to social studies, language, mathematics and music as well as social interaction with students.

Progress

Basic to the validation of the paradigm of teacher education, the Educational Encounter, are specified components of that paradigm which can be systematically manipulated to observe effects on actual achievement. Since April, 1968, a major amount of our time has been directed toward the development of a series of modules that are a part of the professional preparation of the Staff Development Program. These modules are systematically designed instructional packages structured for efficient learner acquisition of specified behaviors. Each module includes a statement of:

I. Objectives

Statement of what specific performance capabilities the participants should be able to do by the end of the module.

II. Rationale

Rationale, including general goals of the module, analysis of the subtasks in the module, the relationship between instructional activities of the module and the objectives, description of the subtasks involved in each activity, evaluation data on the use of the module during pilot study grouping and related references to the module.

III. References

A listing of those references directly related to the topic or content of the module and which would be most relevant to the instructor.

IV. Materials List

In the module, various materials are called for. In this list, they are specified along with the instructional activity with which they are to be used.

V. Instructional Activities

A. Each module begins with a pre-appraisal which is task-related to the module's objectives. Using this as a diagnosis of group or individual performance, the instructor can then select those activities (the modules) which are designated for the objectives the participants need.

B. The instructional activities are presented in a step format as one way to assist participants to achieve the behavioral objectives. Alternative instructional activities are possible and many times will be presented.

C. The appraisal activities are other situations in which the instructor can rediagnose the performance capabilities of his group; based on this he can make the decision to proceed or to go back and reteach.

VI. Duplicated Materials

Materials to be handed out to the students have been assembled in a student work text. They are also included in the module in two sets: one without answers and one with acceptable responses included.

Thus, a module is designed to assist teachers to acquire specific behaviors. Does it? Answering this question involves the procedure for the development of a module. As illustrated in Figure 6, following the initial writing of the module the author collected the materials and taught the module to at least three groups of inservice teachers. Modules developed to date have usually been presented as a class session in a conventional methods course. A member of the staff observed the presentation and maintained a running commentary of the participant reactions, including specific points of confusion. Following this pilot testing of the module, two basic questions were asked:

1. Is it teachable? Can the module be presented as written?
2. Are students able to achieve stated objectives as a result of the experience?

Once the module has been taught in the trial version, it was written and further pilot tests of the module were conducted by other members of the staff.

Following the revision, a first experimental edition is readied for field testing. Up to the point of field testing, the module is generally used only by members of the project staff. Once the module is in the first experimental edition, the module is available to T_2s and T_3s for field testing.

So that feedback information from field testing will be systematic and of the greatest possible use to the project staff, a Module Feedback Form has been designed. The information from field testing provided the basis for revision of the first experimental edition. Following revision, the second experimental edition will be field tested. Once the module is deemed ready, the material specifications are stated and a final edition of the instructor's guide and student section will be prepared for dissemination. In the preparation of the first experimental edition it is anticipated that research studies will be conducted to determine the most effective combination of filter elements for student acquisition of desired outcomes. It is also anticipated that studies to determine the empirical validity of a sequence of behaviors will be possible.

Support for the development of the instructional modules has been provided by the Research and Development Center on Teacher Education of The University of Texas.

III. The Future

From an initial start with ten teachers in 1963 to nearly 9,000 teachers in 1969 and an additional 3,000 [illegible]eduled for involvement in 1970 the task of spanning the chasm between curriculum development and changed classroom experiences for students has been started. A source for an essential ingredient for this change, trained regional and local leadership, has also been created as indicated by the increase from one T_3 in 1963 to 20 T_3s in 1970 and no T_2s in 1963 to 155 in 1970. A third essential ingredient in curriculum improvement: A committed administration in the local school district has been indicated by the adoption of this innovation on the basis of pilot test experience in 91 districts in the State of Texas. As has been indicated with respect to each objective, the means by which the objectives of this project -- namely implementing change -- will be continued after the cessation of federal funding has been described. The planned involvement of more than 3,000 teachers during the summer and the next school year is an adequate indication that federal funds have been used to initiate change and that local resources are now taking over the responsibility for continuing both the initiation and maintainance of that change.

Budget for this report (July 1, 1967 to July 30, 1969) is as follows:

\$537,079.00	total cost
\$101,899.00	total non-federal support
\$306,108.00	total federal support under Title III TL89-10
\$129,000.00	total federal support other than Title III TL89-10
\$86,000.00	from The University of Texas Research and Development Center on Teacher Education
\$43,000.00	from the National Science Foundation through the Science Education Center, The University of Texas

APPENDIX A

THE EDUCATIONAL ENCOUNTER: TOWARDS A PARADIGM OF TEACHER EDUCATION

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Teachers teach, but do students learn?

The complex experience of the teaching-learning interaction is, in reality, an educational encounter. This encounter represents an interaction of individuals with experience ranging from organized subject matter to incidental events. These encounters may or may not have their meaning enhanced by the direction of a more mature "guide" or teacher.

Three criteria must be met for an encounter to be termed educational. To educate means, literally, to lead out of. This definition implicitly suggests that first one knows who is being led; second, where they presently are; and third, where they are going. Thus, an encounter must be considered as a personal event, an event with an intended direction for a behavioral change and based on where the individual is with regard to that anticipated goal.

When the educational encounter is analyzed, some characteristics seem to be clearly identifiable. In an encounter, there is the interaction of individuals--that is, student with students or teachers with students. These interactions usually occur within an instructional context. While instruction imposes some challenges and restraints on the student-teacher interaction, the social-organizational context of the school and community provide additional restraints and challenges upon this encounter. The encounter itself does not exist in isolation. It is preceded by antecedents and is followed by lower remote achievements. The total encounter could be pictured in the following way:

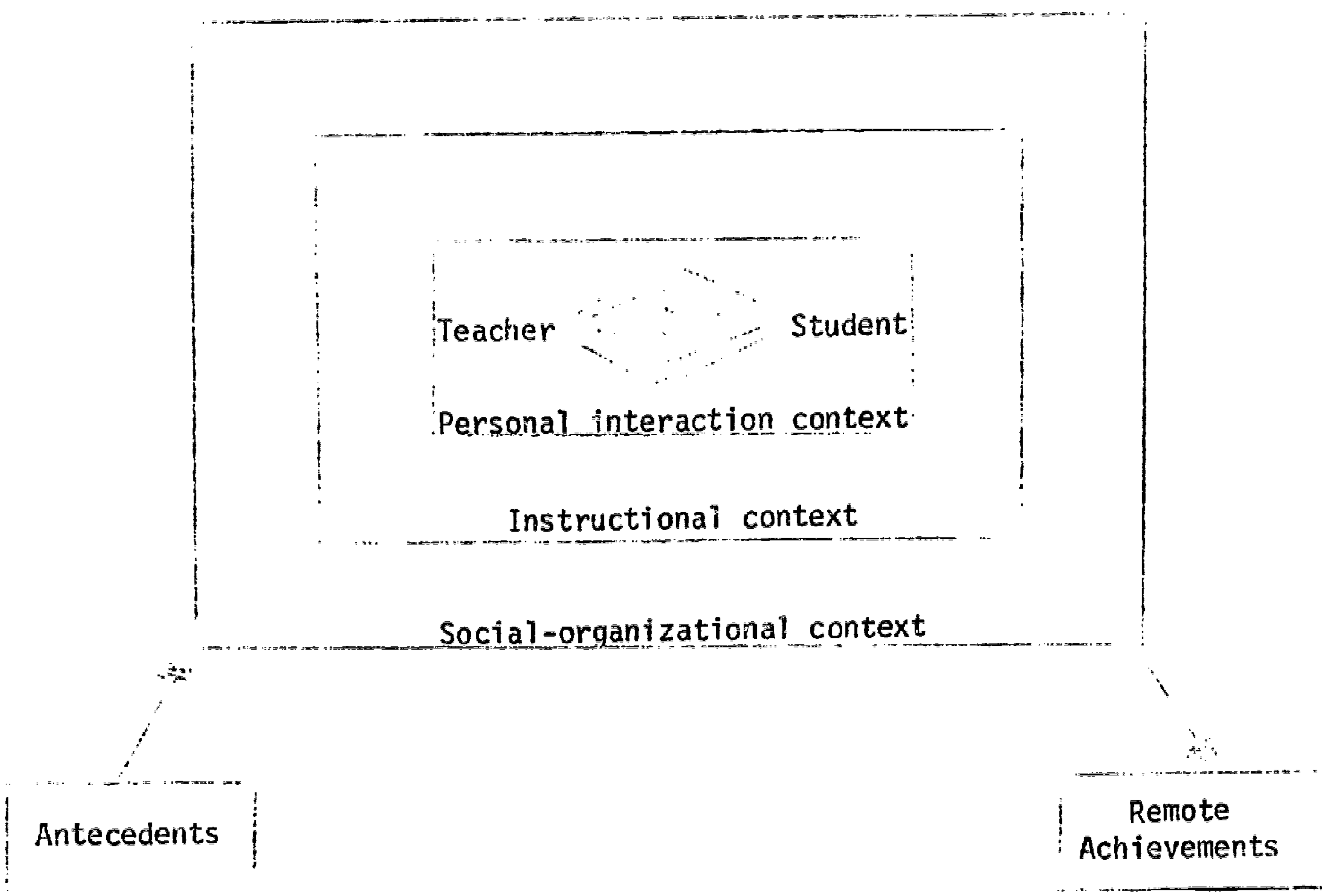


Figure 1

Interaction

Based on the concept of the educational encounter, what the learner does depends upon the varied cues which he perceives. It also depends upon the importance the individual attaches to the cues he perceives or how large these cues seem to the individual. Thus, the task of teaching and learning is the task of processing individual perception of cues and making judgmental responses. An example of the individual perception of a cue is the student's interpretation of a teacher's statement, "Can you." It might be interpreted as an intended direction or as a question, "Are you able?" Such aspects of teaching behavior mediate the communication between the teacher and the student. The implication of the interaction between teachers and students for a teacher education program is that such a program must include information-processing behavior about cues and their interpretation of the teacher as an individual, the student as an individual, and the teacher-student as an interacting pair.

Instructional Context

Added to the context of the interaction of the student with student and student with teacher are the characteristics of the classroom or the instructional context. Students and teachers may perceive these cues differently. For example, with respect to such cues as the location and number of participants in the instruction, desks arranged in rows clearly communicate to the student the intent of the teacher for audience passive participation with single or at best small group "stage center" activity. Desks arranged in clusters of four to six enhance the probability of small group interaction. The instructional strategies of the teacher and student's interaction may be a function of the subject context. Specific instructional tactics will be dependent upon the timing of the task; that is, the introduction of a study, the continuation of a present area of study, or the conclusion of an area of study. Both students and teachers perceive cues and make judgments about their behavior based on what cues are perceived and how these cues are interpreted as fitting both the instructional context and the extent to which this context is relevant, challenging, and restrictive. The implication of the instructional context for teacher education suggests that three kinds of information-processing behavior are essential. The first category is the teacher as a person knowledgeable in subject matter. The second category is the teacher as a designer of instruction for children, and the third category is a teacher as a decision maker in the instructional setting who secures cues and judges them with respect to the children's response.

Social-Organizational Context

Encompassing the instructional context is a social-organizational context. This context includes school organization, community, and the wider environmental context of both student and teacher. The social-organizational context provides more distant cues. It is relevant to note that presently most teachers maintain major control over the instructional context. Hopefully, teachers will share more than a minimal amount of this control with students. However, most teachers and most students have no control over the social-organizational context of the learning encounter. The social-organizational context contains boundary conditions for subject matter, students, and thus for teachers. One can hypothesize that the degree of effective interaction with the instructional context is directly proportional to the clarity with which both the student and teacher perceive the boundaries of the social-organizational context. As a direct implication, it is essential in the teacher education program that information-processing behavior about cues and their interpretation in four areas be identified. The first area is the teacher as a member of a larger system. The second is the students as members of a larger environment. The third area consists of the opportunities and the constraints of the environment on the instructional context of a teacher and student; and fourth, the opportunities for constraints of the environment on a personal context on the interaction of teacher and students.

Definition of Teaching

If the educational encounter includes cues of the personal interaction of students with students and students with teachers, the instructional context, and the social-organizational context, then teaching is (1) the perception of cues; (2) the classification of cues into perceived order; and (3) making judgmental responses to these cues. This leads to the general concept of teaching as being information-processing behavior. Accepting this assumption, the task is then to educate a person to secure information to process that information to act upon that information.

Sequences of Encounters

If the educational encounter is considered as a definable unit of total experience, then it is possible to distinguish two sequences of encounters that are relevant to teacher education. It is now generally accepted that teacher preparation does not terminate with a college diploma but continues as long as the teacher teaches. Evaluation of a teacher education program requires information about the effectiveness of the teacher once he begins his career. The final and only real test of the success of a teacher education program is the terminal achievement of the pupils who are instructed by graduates of the teacher education program. An effective program for the preparation of teachers includes continuing academic and job experience. The resulting teacher education program thus consists of two sequences of encounters: the college sequence and the school sequence. Each sequence has many intricacies and compounding variables of its own in addition to the interaction between the two sequences. Figure 2 (see attached page 6a) is an illustration of these sequences.

College Sequence

The college sequence of teacher preparation begins with the student entering the university. This sequence has two basic components: the academic foundations or liberal arts component, and the professional component. In general, prospective teachers receive the same academic foundation courses as liberal arts majors, foreign language majors and others. In addition, little attempt is made to tailor courses to any unique needs of prospective teachers. On the other hand, the teacher education program is supposed to be ideally suited to the needs of future teachers.

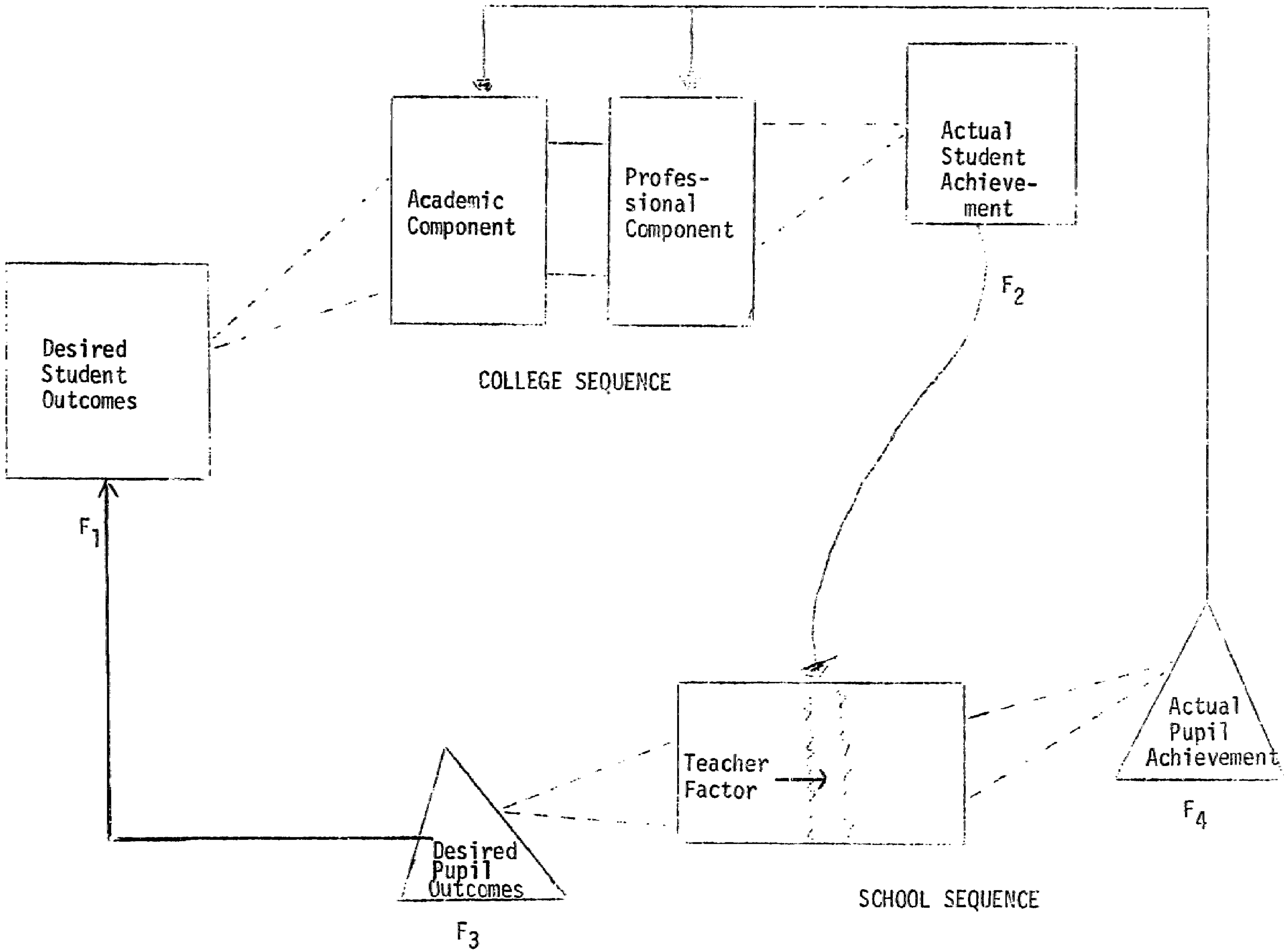

Desired Student Outcomes
Academic Component
Profes-sional Component
Actual Student Achieve-ment
COLLEGE SEQUENCE
F_1
F_2
Teacher Factor
Actual Pupil Achievement
F_4
Desired Pupil Outcomes
F_3
SCHOOL SEQUENCE

Figure 2

Upon entering college, students have a repertoire of behaviors, specific personality characteristics, values, expectations, and academic competencies. As a result of experiencing the college sequence of encounters, the student graduates and begins his professional teaching career. At graduation the student has acquired new behaviors and competencies as well as changes in old behaviors and values and expectations. At this time the college sequence graduate enters the school sequence as a teacher.

School Sequence

Like the student entering the college sequence, pupils enter school with a repertoire of behaviors as well as certain developing characteristics including values and expectations. As a result of the school sequence of encounters, the pupil leaves the school with modified old behaviors and many newly acquired behaviors, values, and expectations. One of the main factors contributing to the growth of pupils is the teacher. A large portion of the effectiveness of the teacher factor should be attributable to the college sequence.

As can be seen in Figure 2, pupil achievement in the school sequence should act as feedback loop, providing a basis for accepting revision for part (or parts) of the academic foundation or the professional components. This feedback loop is one way of improving the encounter to the extent that pupil learning is the result of the teacher.

In summary, then, there are two sequences of educational encounter essential in teacher education: the college sequence and the school sequence. The prospective teacher enters the college sequence with certain behaviors and receives training in both academic and professional components. The actual achievement of the student is a range of attainment in both number and level of desired behaviors. Likewise, the pupil enters the school sequence and leaves the school sequence with certain acquired behaviors. From research studies, it would seem possible to determine how effective the teacher is in contributing to pupil achievement. Knowledge thus gained should be the basis for revising the components of the college sequence.

Four Significant Focal Planes

Based on the sequences of the educational encounters in Figure 2, there are four specific opportunities at which comprehensive appraisal of progress is essential. It is at these points that the range of experiences appear to be focused; they represent key decision points in determining what kinds of programs should be prescribed and what kinds of modifications in the program ought to be made. These four focal planes are: (F_1) the desired outcomes of college students; (F_2) the actual achievement of college students; (F_3) desired outcomes of pupils; and (F_4) actual achievement of pupils (see Figure 2).

Referring to the instructional context of Figure 1, the desired outcomes of the college sequence of encounters have been generated by at least three referent groups. Schools and society continually are requiring certain competencies of teachers; the professional educator has his set of expected behaviors; and the student entering the program has his set of desired outcomes. These three referent groups, however, do not always have a congruent set of expectations. Indeed, it appears that there are some expectations that may well be perceived as being in conflict. Unless there is a common understand and agreement on the desired outcomes, the effectiveness of the teacher education program will be seriously reduced.

Categories of Desired Outcomes

Using the information gained from the three referent groups for the instructional context, it is possible to specify three categories of desired outcomes for the college sequence. For each of these categories, a set of behaviors can be specified based on the concern level of the student. Basic to our frame of reference is that changed behavior will be in response to perceived cues. If changed behavior is a response to perceived cues and if concerns bias that which we perceive, then it follows that the concern level of the student must be one basis for sequencing behaviors within categories.

The three categories of behaviors for the instructional context are:

1. Task competence; that is, awareness of a specific task and experience in doing that task.

2. Instructional design; that is, the pre-active phase of teaching. The translation of the task into experiences suitable for pupils. This includes analysis of the task, specifying behavioral objectives for the task, selecting alternative instructional experiences and designing pre- and post-appraisal activities.

3. Instructional decision making; that is, the interactive phase of teaching. The act of using instructional materials with students and with this use the identification of effective strategies for interacting with pupils. A second outcome of this phase is the opportunity to secure feedback on the instructional design for utilization in its modification.

Figure 3 illustrates how the behaviors of the instructional context are sequenced based on the concern of the student.

A note of caution should be inserted here. Figure 3 represents an hypothesized sequence based on experience. Systematic research is needed to determine the empirical validity of this sequence and its relevance to the concern level of the student.

Encounter Filters in the College Sequence

Clearly defined desired outcomes are important but are they the necessary and sufficient condition for successful achievement of these outcomes? There appears to be a series of filters between the entry and the exit of the encounter. These filters are:

1. the student;
2. the instructor;
3. the conditions that surround the learning situation; and
4. the interaction of the instructor with the student.

To facilitate student achievement of desired outcomes in the college sequence, a system for learning must be established. In this system (see Figure 4), these four filters contribute to systematic achievement. The filters are subdivided into specific elements which can be utilized in an instructional situation (see Figure 5). It should be pointed out that various sample elements described here are very large in scope and greater specificity of elements within the filter is possible.

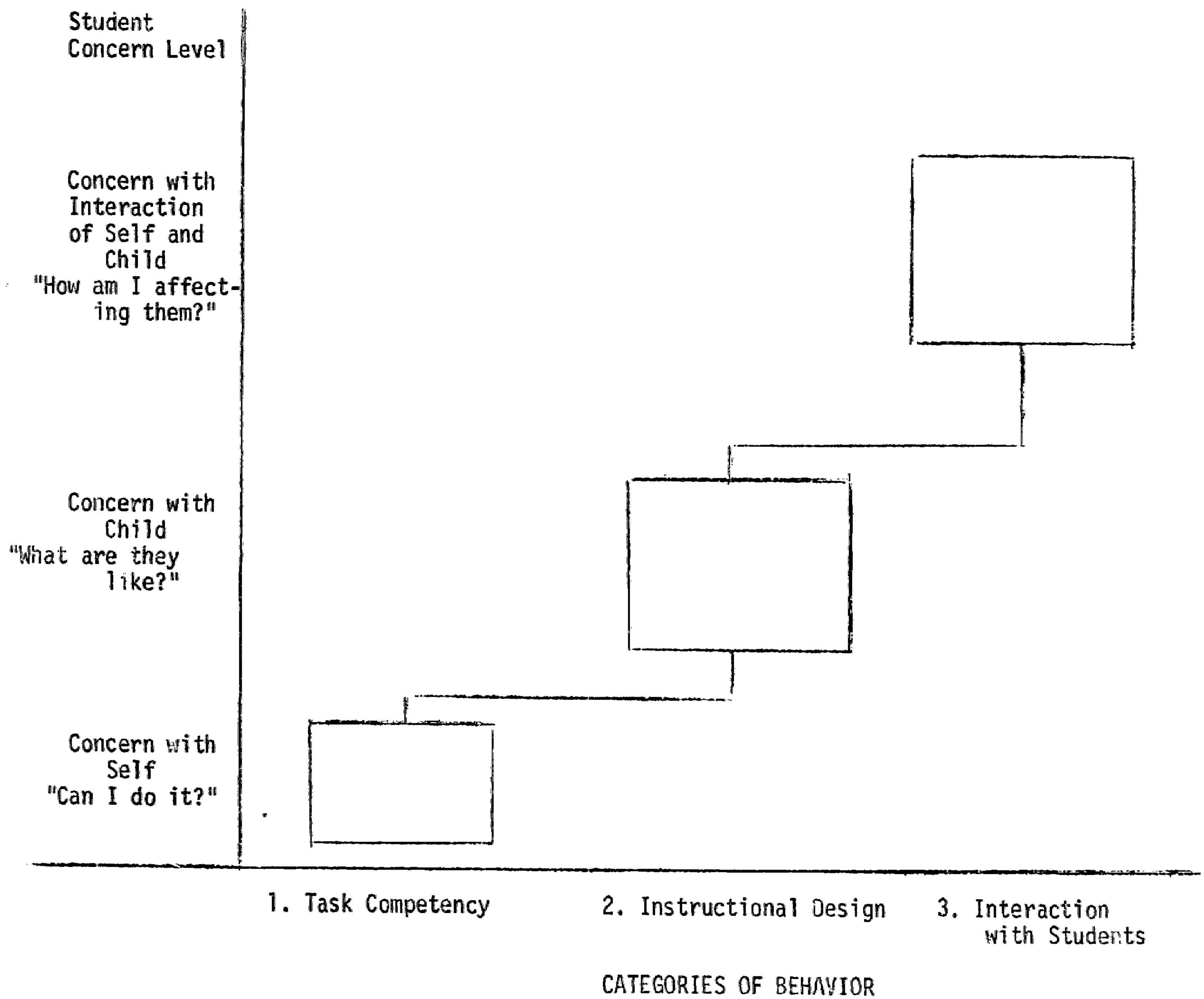
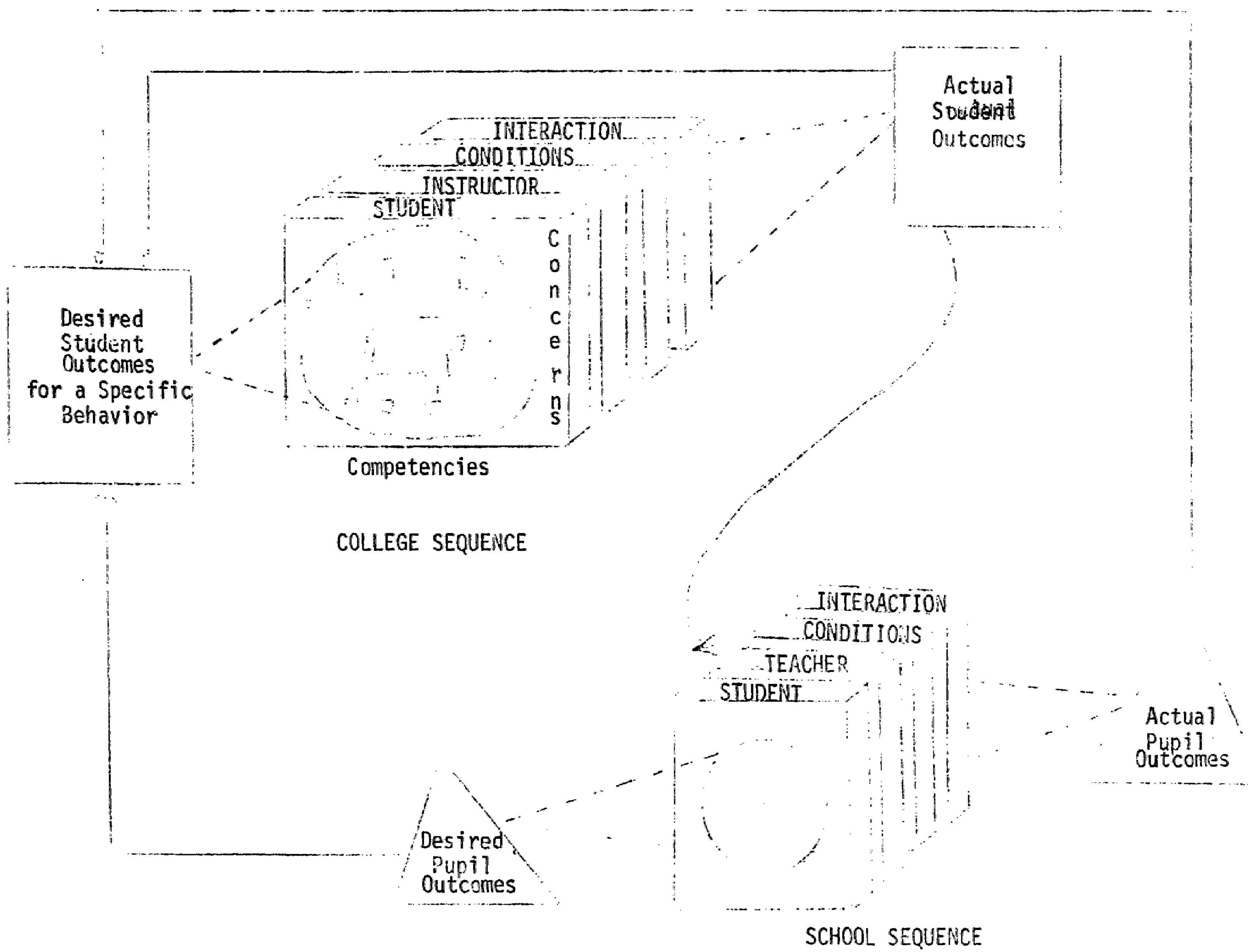
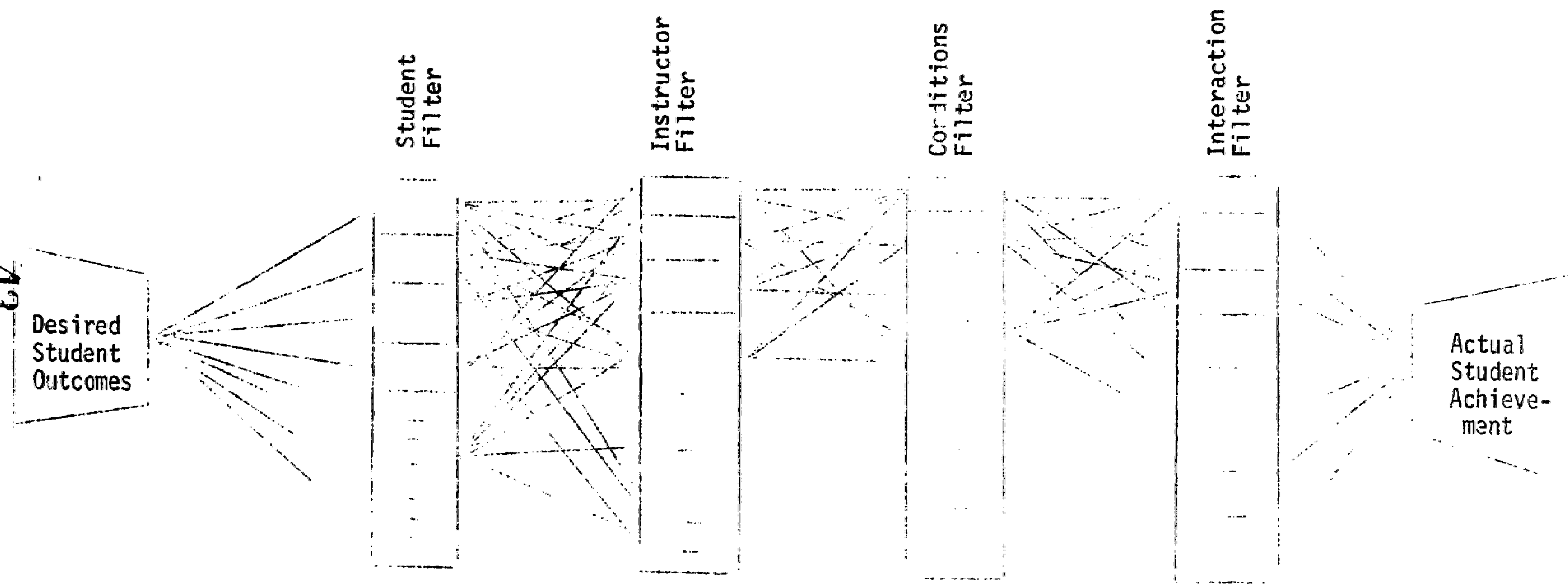

Student
Concern Level
Concern with
Interaction
of Self and
Child
"How am I affect-
ing them?"
Concern with
Child
"What are they
like?"
Concern with
Self
"Can I do it?"
1. Task Competency
2. Instructional Design
3. Interaction
with Students
CATEGORIES OF BEHAVIOR

Figure 3



INTERACTION
CONDITIONS
INSTRUCTOR
STUDENT
Concerns
Actual Student Outcomes
Desired Student Outcomes for a Specific Behavior
Competencies
COLLEGE SEQUENCE
INTERACTION
CONDITIONS
TEACHER
STUDENT
Actual Pupil Outcomes
Desired Pupil Outcomes
SCHOOL SEQUENCE

Figure 4



COLLEGE SEQUENCE

Figure 5

Student Filter. The first filter to be considered is the student filter. What internal conditions and variables of the learner affect his actual achievement? These elements include such items as intelligence, aptitude, age, sex, mental maturity, etc.

Instructor Filter. The instructor filter is a broad classification that includes such elements as a full professor, a guest lecturer, a graduate teaching assistant, and a computer. Another example of an element in this filter is a textbook or printed program material.

Conditions for Learning Filter. Conditions for learning would contain such elements as whether instruction occurs in a classroom setting of 30 or at a computer console on a 1 to 1 basis or perhaps a seminar with six students and a group leader. Other types of conditions can be specified and placed in cells within this filter.

Interaction Filter. Once the elements of the conditions for learning filter and the instructor filter have been identified, there must be an interaction with the learner--in this case, the student. The type, frequency, and variability of the interaction behaviors will depend upon what the conditions for learning are, as well as what the instructor factors are. One example might be the interactions expected if the conditions for learning element is a computer console and the instructor element is a compter which will result in different kinds of combinations than if the conditions element is a classroom with 30 students and the instructor element a full professor.

Encounter Filters in School Sequence

In a similar way pupils' achievement at the focal planes 3 and 4 is directly related to the four filters of the instructional context. For example, when the conditions for learning filter is considered, various elements of this filter can be identified such as normal classroom situations where the teacher uses a question and answer cycle, laboratory investigations or the watching of an ETV program. Elements of the instructor filter in the school sequence should have a great deal of specificity since the teacher has just graduated from the college sequence. His repertoire of behaviors and his degree of achievement of this repertoire have been specified. The interaction filter again includes such things as whether it is pupil-teacher interaction, pupil-tape recorder interaction or pupil-computer interaction, etc. The student filter is complex and contains many difficult to specify items, such as IQ, mental maturity, attitudes, aptitudes, class achievement, sex, and so forth. Here again, though, each element within each filter affects the actual achievement of the desired behaviors. By varying the elements chosen for the achievement of a specific behavior, the sequence of elements which results in the greatest individual pupil achievement of each behavior could be identified.

It is hypothesized that the relative contributions of varying elements of a filter are probabilistic. Once the characteristics of the individual learner have been specified, the actual element employed for a given filter will contribute a certain amount to learner achievement. It is further hypothesized that the amount of contribution by a specific element is quantifiable relative to other elements in the filter.

Summary

Teachers teach, but do students learn?

The search for operational answers to this question has led to many alternative descriptions of the complex encounter between students and teachers. Examination of this encounter suggests that it includes identifiable outcomes for the encounter, specific components for the encounter, and the actual student achievement as a result of the encounter.

Further analysis of the encounter suggests that the central core is inter-personal interaction of teachers with students and students with students. Surrounding this interaction are those topics for intended instruction--or the context of instruction. Enveloping the context of instruction is the social-organizational context of the school and society from which the goals of instruction are secured. Each of these three groups--student, teacher and school-- contribute to the description of desired outcomes of the encounter and, to some extent, each contributes to actual learner achievement. Encounter sequences are identified on both the college level and the school level.

When one considers the desired outcomes of instructional context at the college level, input from the schools, professional education, and the student has resulted in the specification of three categories of behavior.

They are:

1. Competency in doing the task;
2. Design of instruction or pre-active phase of teaching; and
3. Instructional decision making or interactive phase of teaching.

The same three referent groups again have an input into the actual encounter both with the college and school levels. Filters of this encounter have been described as those factors which are directly related to the achievement of specific objectives. These filters include:

1. the student;
2. the instructor;
3. conditions for learning; and
4. the interaction between instructor and student

The primary goal of teacher education is for teachers to enjoy teaching and for students to enjoy learning. Within the context of specific disciplines, this is translated into the primary goal of the Mathematics-Science Module Building Group that is for teachers to enjoy teaching mathematics and science and for students to enjoy learning mathematics and science.

APPENDIX B

FINAL REPORT

1968

LEADERSHIP CONFERENCE

Science Inservice Project

Curriculum Demonstration Center
of the
Austin Independent School District

and

Science Education Center
of
The University of Texas at Austin

and

The Research and Development Center
on Teacher Education
at
The University of Texas at Austin

David P. Butts

R. Scott Irwin

FINAL REPORT
1968
LEADERSHIP CONFERENCE

Science Inservice Project
Science Education Center
The University of Texas at Austin
July 15 - August 2, 1968

I. INTRODUCTION

The 1968 Leadership Conference at The University of Texas was designed primarily for individuals with responsibility in continuing teacher education programs in the implementation of new curriculum in science in the elementary school. These individuals came from school districts (T_2) and Regional Service Centers (T_3) and represented a cadre of resource individuals for the task of implementing improved science curriculum in elementary schools. Selection for participation in the conference was based on recommendations of school district administrators or Service Center directors.

A second group of participants included classroom teachers (T_1) who were concerned with improving their approach to the teaching of science. Many of these used this opportunity to secure college credit for the conference and all voluntarily participated in the conference. Table 1 summarizes the background of the participants.

Table 1
Professional Background of Conference Participants

Classroom Teachers (T_1)	
Primary	31
Intermediate	24
Lead Teachers (T_2)	26
Regional Service Center Staff (T_3)	10
Science Supervisors and Administrators	5

II. OBJECTIVES OF THE CONFERENCE

Because of the nature of the participants, there were two sets of objectives for this conference. At the completion of the conference, the classroom teachers (T_1) should be able to:

1. Identify and demonstrate the use of teaching strategies which are compatible with the philosophy of Science - A Process Approach. This should include such strategies as:

   a. describing situations in which students can raise questions, construct procedures, and demonstrate appropriateness of conclusions;

   b. describing classroom situations which illustrate willingness to wait for appropriate responses rather than tell the "correct" answer;

   c. identifying learning situations which involve active participation rather than passive listening;

   d. describing questions which are posed to secure thinking rather than those with a single "correct" pat answer from the student;

   e. describing learning experiences in which students have the satisfaction of completing a worthwhile task;

   f. distinguishing between classroom experiences that are directed toward behavioral objectives and those that are "side excursions" into other areas;

   g. describing student achievement in terms of observed behavior rather than opinion of what behavior ought to be present;

   h. identifying goal achievements through assessment of student behavior.

2. Demonstration of the acquisition of specific behaviors and knowledges which are part of the structure of Science - A Process Approach, including the following:

   a. distinguishing similarities and differences in objects and events;

   b. distinguishing between observations and inferences;

c. identifying the unit or units of measurement appropriate to a particular task;

d. stating observations in terms of precise position or motion description;

e. identifying shared properties of objects or events and using these in the construction of classification systems;

f. constructing statements of expected observations based on past observations;

g. stating observations in quantitative terms when appropriate;

h. constructing a scheme for recording data so that interpretation of that data may be distinguished from the data.

In addition to the above objectives, at the end of the conference each of the school district leaders (T_2) or the Regional Service Center staff (T_3) should be able to:

1. Describe the curriculum, Science - A Process Approach, its rationale and psychological basis;

2. Construct science experiences for students which illustrate the programs rationale;

3. Apply the structure of Science - A Process Approach to directing learning experiences with students;

4. Describe a teacher education program for Science - A Process Approach;

5. Demonstrate the teacher education program with classroom teachers;

6. Identify classroom events which are not in resonance with the fidelity of Science - A Process Approach;

7. Construct alternative solutions to the problem of implementing programs back home; i.e., identify sources of resistance to change and apply appropriate strategies. This includes demonstrating the initiating, the intervening, and the receptivity skills such as involved in giving and receiving feedback.

The Leadership Conference was organized around a dual schedule with T_3s and T_2s participating in a variety of leadership training sessions each morning. Then these T_2s and T_3s assumed the role of instructor for the afternoon sessions in which classroom teachers (T_1) were the participants.

In order to make each person's involvement in the total conference as relevant as possible to his expected role upon the completion of the conference, all participants were assigned to one of six groups. Activities within these sub-groups were based on grade levels 1-6. Although some general sessions involved all participants in one large group, much of the 15 days of the conference were spent in the sub-group sessions. The agenda and complete program with a roster of participants are in Appendix A.

During the morning sessions, the T_2 and T_3s constructed alternative strategies for conducting inservice programs and a variety of sequences for implementing new science curriculum. They spent much time working on the task of helping classroom teachers implement a program which included designing awareness conferences for the school administrators and decision-makers for allowing the program to start. Additional time was spent in developing strategies for working with building principals and involvement in the classroom.

Specific activities during the morning sessions for T_2s or T_3s involved sessions dealing with such problems as:

a. What decisions must be resolved while planning to conduct an inservice session?

b. What alternative inservice modules or teaching education sessions to guide in the planning and conducting of inservice are available?

c. What alternative activities to those suggested in the existing guides can or should be constructed?

d. What is the role of lead teachers conducting demonstrations with children in science?

e. What is the place of low ratio teaching and the accompanying feedback for inservice?

f. How do you handle inquiries about science equipment and materials?

g. What is the classroom teacher's own perception of her role in a process centered program for children?

h. How do you conduct "Awareness Conferences" for schools not familiar with new programs and in this way handle concerns of administrators?

i. What should follow-up activities include?

j. What does research say about the new science programs and the kind of inservice which should or should not accompany their adoption by a school district?

Since T_2s and T_3s must work with adults in the change process, these experiences included a study of their own interaction with others. The study included the use of:

a. Fishbowl technique in which each group works with a person trained in the group process and the trainer observes the group while it works on a task (e.g., deciding how to implement a new curriculum in science) and furnishes feedback to individuals on moves, techniques, habits of interaction that either help or hinder attainment of the group task; other observers then give their feedback in terms of specific suggestions for changes in behavior to be tried; the group returns to the task and tries to practice the suggested behaviors.

b. Meeting and coping with overt resistance; that is a pool of back-home problems anticipated or actually encountered in trying to get new programs in science ins uted was developed by participants. Suggestions for solution strategies were given by participants, and then they tried role-playing.

c. Role playing. The suggestions to get some practice at coping with a range of responses. Again feedback played a part in the training. After trying a role, the group coached a participant, and he tried again. The director of the institute and other members of the staff served as the role-person to be changed. The experience of these three in implementing new programs providing them with a wide range of type of resistance different kinds of school personnel offer. Conferees "met" all these types in role-playing.

d. Feedback. Techniques for getting and using feedback were practiced in the ways described so far but in one additional way. The groups regularly return reaction sheets to sessions in which they participated. Remarks were collated and returned to the group and the instructor used them as a vehicle to teach the group on how to give and take feedback. Initially, participants were hesitant to be candid and many times they did not know how to be con tructive. In the necessity to manage their feelings about saying something perceived to be critical, they omit the part of feedback which is critical to change, namely constructive alternatives. With training, the group came to perceive direct feedback as vital to program planning. When that happened, both the giver and the receiver were ready to profit from it.

The afternoon sessions for T_1s were conducted by the T_2s or T_3s. These sessions were planned by the lead teachers during part of their morning sessions and included a balanced blend of sessions involving both the preactive and the interactive phases of teaching. Included among some of the preactive sessions for teachers were:

a. An introduction to Science - A Process Approach.

b. Setting individual goals for the conference.

c. Planning to teach children in a low-ratio situation.

d. Sessions on each of the basic processes of Science - A Process Approach: Observing, Classifying, Communicating, Inferring, Measuring, Using Space/Time Relationships, Using Numbers, and Predicting.

e. Stating and sequencing behavioral objectives for instruction.

f. Constructing alternatives to a written exercise.

The sessions directed toward interaction with children were:

a. Low-ratio teaching involving more than 100 children whose parents volunteered to bring (some stayed to watch) and pick up their children for an hour of science excitement.

b. Feedback, giving and receiving constructive observations of one's teaching.

c. Observing demonstration classes taught by a lead teacher.

d. Practice in making instructional decisions based on a filmed sequence of a classroom situation.

At the end of the conference the T_2s and T_3s were given the opportunity to give specific feedback as to how they perceived the relevance of the conference to their perceived needs (See Appendix B for a copy of Operation T Blast). All six teams rated the experience of making presentations to the T_1s as the most useful part of the conference. The discussion of patterns and content of the inservice session was the second most useful aspect. In general the fishbowl type of sessions were rated as the least valuable; for example, the fishbowl experience in how to structure low-ratio teaching was given the least useful rating. Table 2 lists the sessions as ranked by the group as being most useful to them. Table 3 specifies how sub-groups perceived the total conference.

Based on feedback at the end of the conference (see Appendix B for Feedback Form) the T_1s rated the teaching demonstrations as a positive contribution (44 and 41 on a 61-point scale). They rated the opportunity with team leaders as quite important (48).

The T_1s described the opportunities to work with other teachers as instructors as most helpful. Some of these specific comments were:

> "We received a lot of help from these people who've had some experience with the process approach."
>
> "They took time to answer questions and explain things to us on a one-to-one basis."
>
> "The lead teachers provided us with a real sense of security. We had not only lead teachers but workshop staff who always took time and were willing to help."
>
> "Very helpful; they really communicated."

Constructing an exercise was perceived to be the least useful by the T_1s while the session on Behavioral Objectives, Communicating and Classifying, Communicating and Predicting, were seen to be the most useful. Specific comments on the Bheavioral Objective sessions were:

> "It gave me a much better understanding of good objectives."
>
> "There wasn't any doubt when the session was over as to behavioral or non-behavioral objectives."

Table 2

T_2s and T_3s Ranking of Conference Sessions

1. Presentation of sessions to T_1s
2. Session on the pattern and content of inservice programs
3. Team level conferences with team leaders
4. Organizing the structure of an inservice program
5. Analysis of the structure of an inservice program; the preactive and interactive phases
6. Analysis on why have demonstration classes
7. Participation in low ratio teaching
8. Overview of the entire conference
9. Fishbowl on planning an inservice session
10. Review of the instructor's guide and resource materials
11. Role playing on film and feedback techniques
12. Constructing an exercise
13. Review of research results
14. Fishbowl on planning an Awareness Conference
15. Handling questions of school administrators and supervisors
16. Analysis of equipment and prices
17. The self-diagnosis through pre- post-testing.
18. Presentation of the observation session by one member to the entire group
19. Fishbowl on how to structure the situation for low-ratio teaching

Table 3

Grade Level Team	Most Useful	Least Useful
1	Discussion of pattern and content of inservice programs; Organizing the structure of an inservice program	Presentation of the Observation session to the total group; Fishbowl on how to structure the situation for low-ratio teaching
2	Presentation of the Observation session; Analysis of why have demonstration classes	Review of research results; Fishbowl on planning an Awareness Conference
3	Presenting sessions to T_1s; Team level conference planning time	Fishbowl on how to structure the situation for low-ratio teaching; Fishbowl on planning an Awareness Conference
4	Participation in low-ratio teaching; Presenting sessions to T_1s	Analysis of equipment and prices; Pre- post-testing
5	Presenting sessions to T_1s; Organizing the structure of an inservice program	Presentation of the Observation session to the total group; Fishbowl on how to structure the situation for low-ratio teaching
6	Team level conference planning time; Presenting sessions to T_1s	Presentation of the Observation session to the total group; Fishbowl on planning an Awareness Conference

"Excellent sessions."

"The action words provided the key to a central behavioral objective as well as what to look for in the child's performance."

The opportunity to work with children during a college course was a new experience for most of the participants. The experience was consistently rated as one of the most useful experiences of the conference. In describing how they felt about the experience, their comments were:

"The planning was well done; all materials were ready at the station."

"The positive enthusiasm with which the task of low-ratio teaching was described to classroom teachers had a lot to do with how well they received it."

"The congenial manner in which T_2s helped the T_1s plan their lesson helped everyone relax."

"The experience gave me a good beginning picture of what this process approach is all about."

"I now know an approach to teaching a child that I did not know previously."

"As a teacher of children I learned I must reconstruct my questions so that I am getting information, not telling it."

"Being confronted with two children of different ability in a one-to-two lesson really dramatizes the kinds of individual differences we don't always detect in a class of 28 children."

"I now feel more secure in teaching children in a process approach. It wasn't nearly as frightening as I expected."

"Most of the T_1s observed the kind of boundless joy children can display in a real learning situation and they enjoyed the chance to work with a specific exercise at their grade level."

Although the session on giving and receiving feedback was not rated high (42), it did elicit some insightful comments:

> "It was the most outstanding of all sessions."
>
> "Perhaps I can now offer more specific help to my student teachers."
>
> "This provided some great rules for anyone to follow in sharing observations."
>
> "It was enjoyable, and it sure got the point over."
>
> "I never enjoyed a more candid, constructive look at my own teaching."

Grade level as a contributor to the T_1s' perception of what they had found relevant was rather obvious. Table 4 summarizes this.

Table 4

Grade Level	Most Useful	Least Useful
1	Behavioral Objectives	Teaching demonstration
2	Using numbers, communicating, classifying, measuring	Observing
3	Measuring	Using numbers
4	Measuring	Constructing an exercise
5	Measuring	Constructing an exercise
6	Communicating and predicting	Using space/time relationships

It has been said that the total may, on occasion, be more than the sum of its parts. This apparently was true for the entire conference. Its total rating (53) was higher than the rating for any individual part. Some comments which reflect this rating, however, were:

"A great learning experience! The demonstrations were particularly helpful."

"My classroom materials are now more easily interpreted."

"Before this conference, science was some simple experiments I squeezed into my social studies units, if there was time. Now I can't wait to return to my classroom."

III. EVALUATION

A keystone of the conference was the emphasis on self-diagnosis. "Know thyself--thy strengths and deficiencies" was a unifying theme. Throughout the conference all participants spent time with two diagnostic instruments, Teacher Profess Measure and Instructional Decisions Test, to assist them in determining specific areas which needed intense attention. This information was available the day after taking the instrument and was then utilized in the planning of instructional activities.

The Teacher Process Measure is an instrument developed by the Commission on Science Education of the American Association for the Advancement of Science to measure competence in using basic science processes in solving problems. Results for all participants are shown in Table 5.

Figures 1 to 9 are the comparisons between T_1s, T_2s, and T_3s on both total and sub-scores. Examination of these figures suggest that T_3s made the greatest gain.

Table 5

TEACHER PROCESS MEASURE: MEAN SCORES

Max - 49 Form A and B

Grade Level	Pre	Post	Change
1	28.7	38.2	9.5
2	22.2	30.8	8.6
3	25.4	40.2	14.8
4	29.6	40.7	11.1
5	30.5	43.2	12.7
6	28.2	32.1	3.9
7	30.3	40.0	9.7
OVERALL MEAN	27.4	34.5	7.1
Lowest	5	10	
Highest	47	48	
Range	42	38	

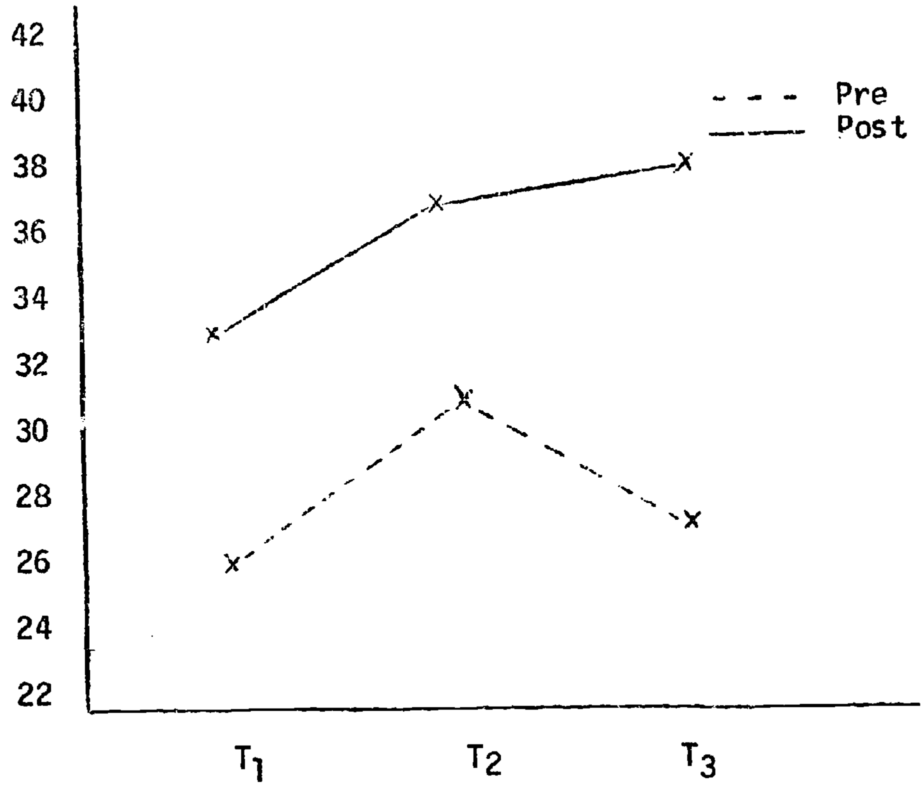


Figure 1
Teacher Process Measure
Total Score

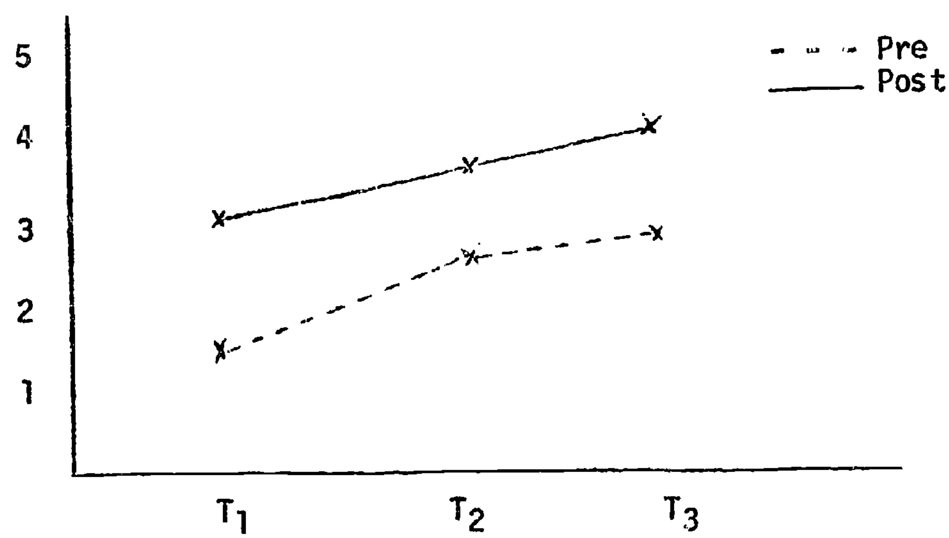


Figure 2
Teacher Process Measure
Classifying Sub-Scores

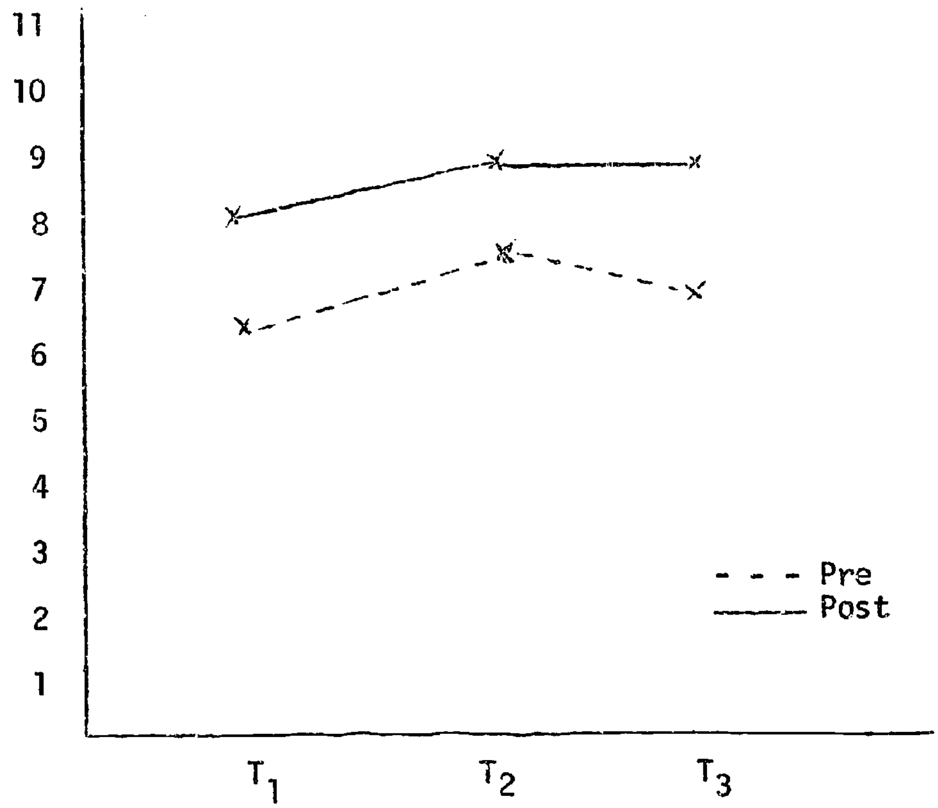


Figure 3
Teacher Process Measure
Predicting Sub-Scores

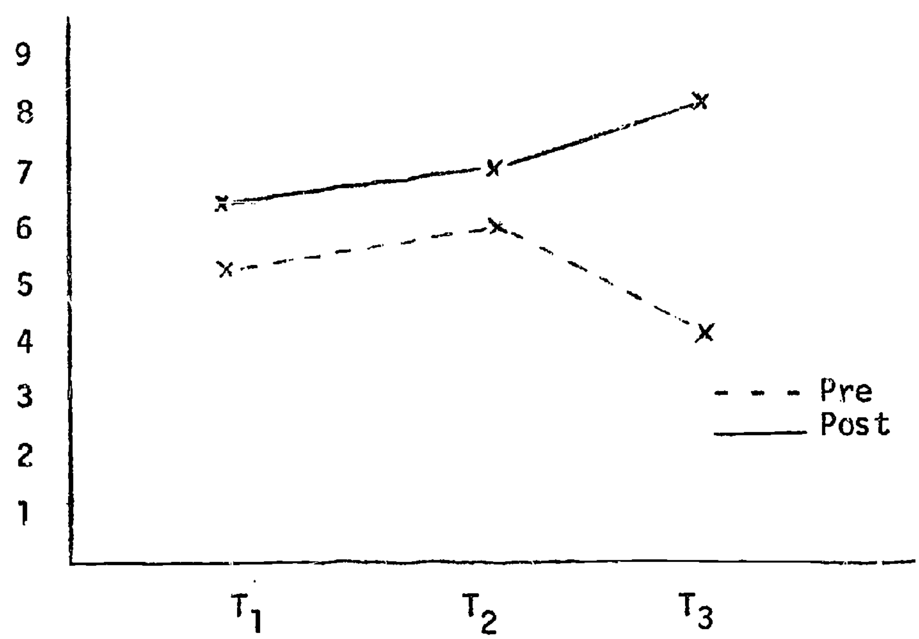


Figure 4
Teacher Process Measure
Inferring Sub-Scores

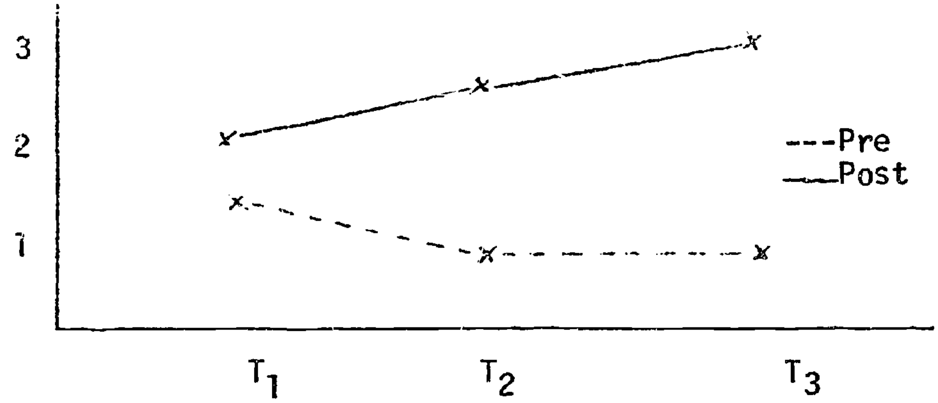


Figure 5
Teacher Process Measure
Measuring Sub-Scores

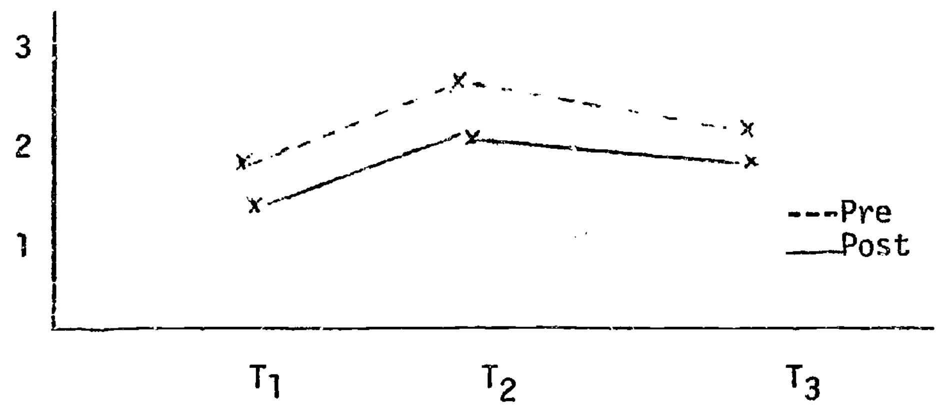


Figure 6
Teacher Process Measure
Using Number Sub-Scores

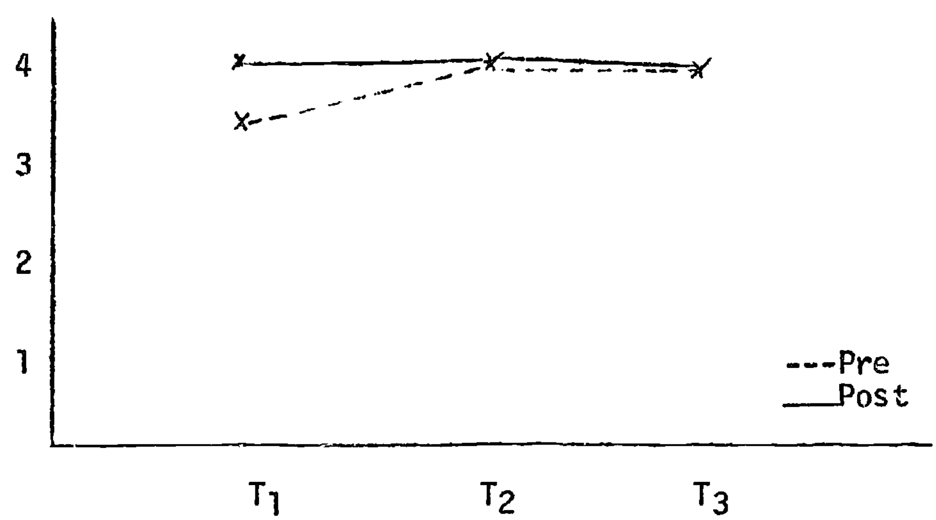


Figure 7
Teacher Process Measure
Observing Sub-Scores

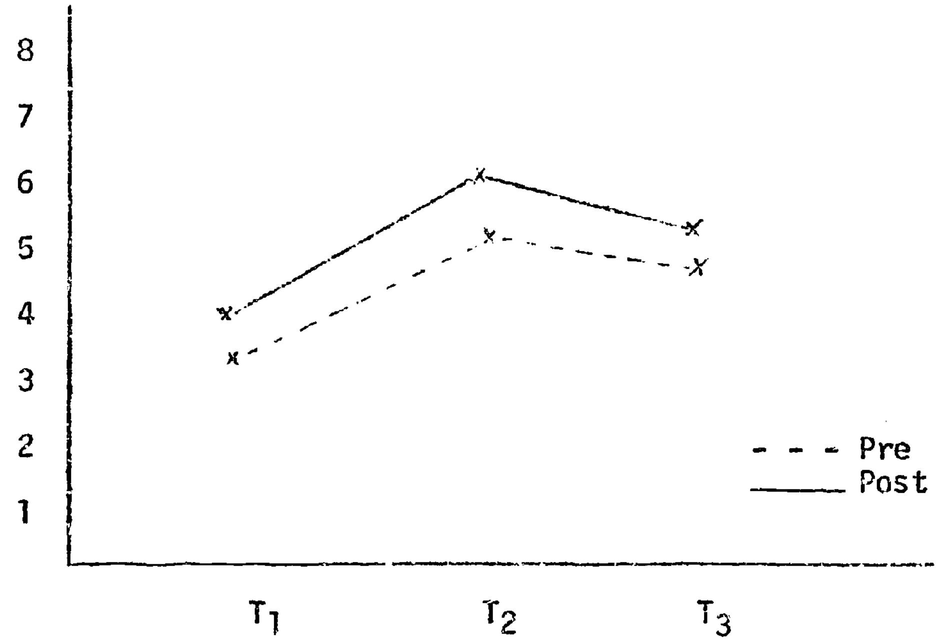


Figure 8
Teacher Process Measure
Space/Time Relations Sub-Scores

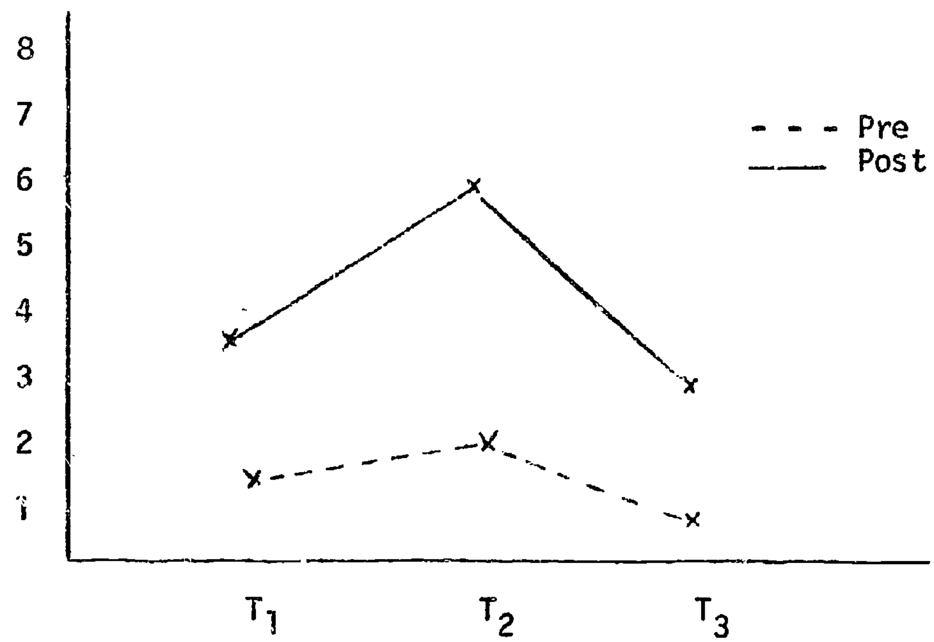


Figure 9
Teacher Process Measure
Instructional Objectives Sub-Scores

A second set of outcomes for the conference included interactive behavior. The Instructional Decisions Test is a set of filmed classroom sequences which presents an instructional problem. As a classroom session is in progress, the film is stopped and participants describe "what the teacher should do next." Figures 10 to 14 illustrate the comparisons of scores of the T_1s, T_2s, and T_3s on parts of this instrument. Clearly, the T_1s show the greatest change.

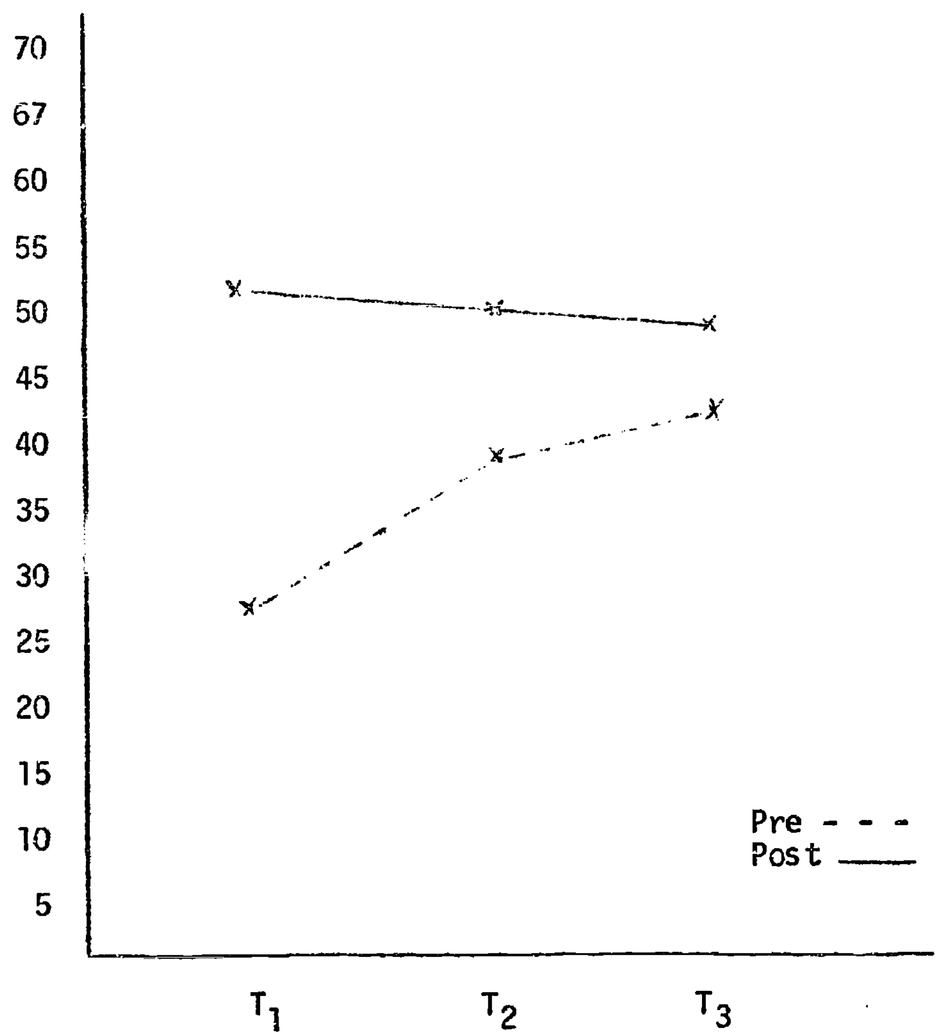


Figure 10
Instructional Decisions Test
Total Score

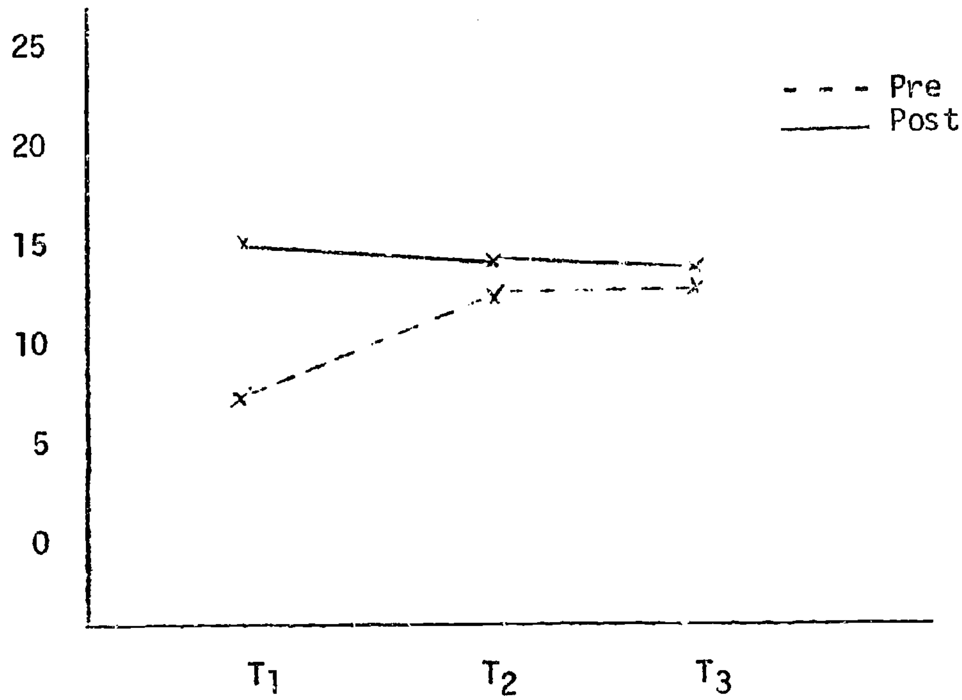


Figure 11
Instructional Decisions Test
Behavioral Objectives Sub-Scores

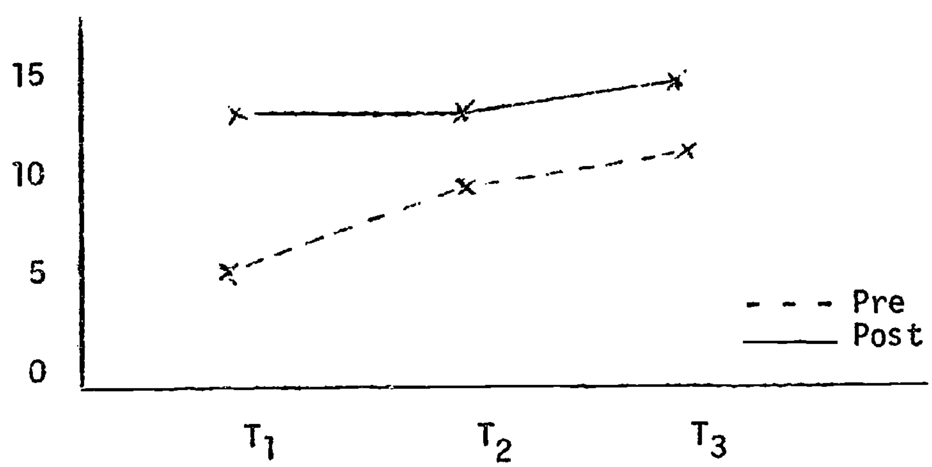


Figure 12
Instructional Decisions Test
Handling Children's Responses Sub-Scores

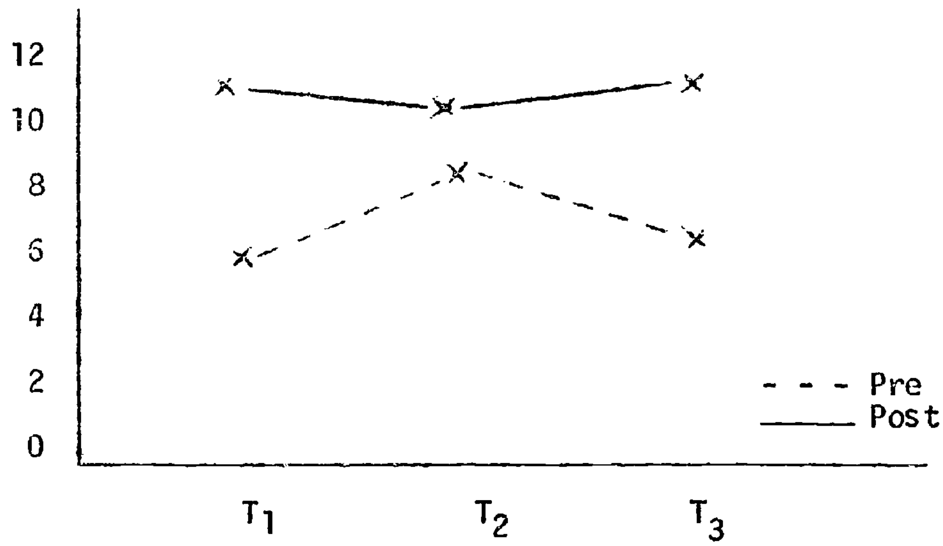


Figure 13
Instructional Decisions Test
Constructing Instructional Strategies Sub-Scores

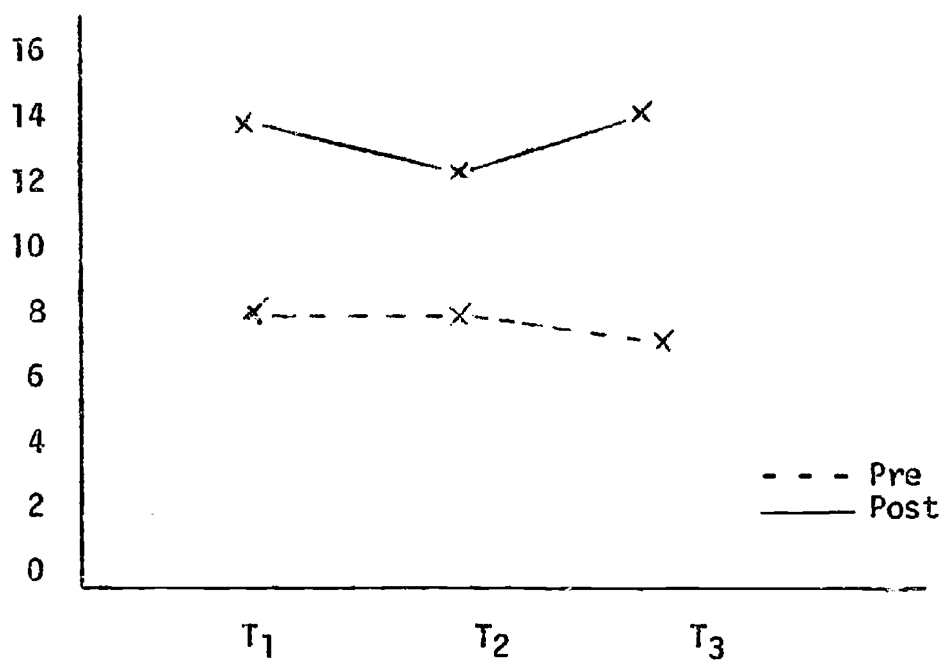


Figure 14
Instructional Decisions Test
Rationale for Strategies Sub-Scores

APPENDIX A

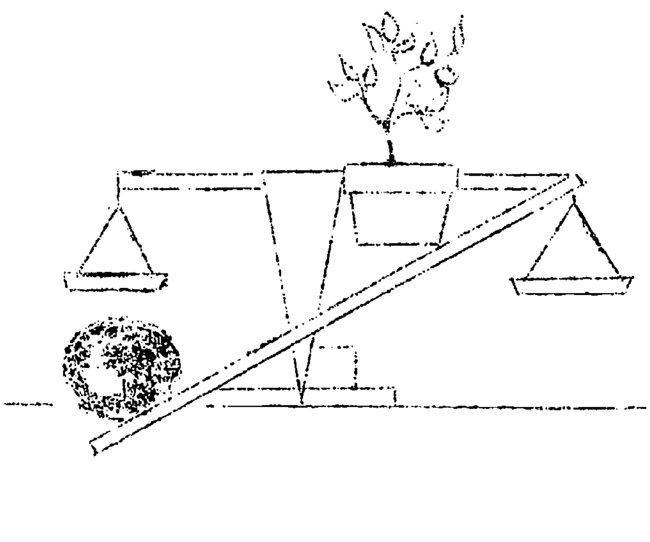
CONFERENCE AGENDA

5TH SCIENCE CONFERENCE

FOR TEACHERS USING

A PROCESS APPROACH TO

ELEMENTARY SCHOOL SCIENCE



CASIS ELEMENTARY SCHOOL
AUSTIN INDEPENDENT SCHOOL DISTRICT

SCIENCE IN-SERVICE PROJECT
SCIENCE EDUCATION CENTER
THE UNIVERSITY OF TEXAS AT AUSTIN

CURRICULUM DEMONSTRATION CENTER
AUSTIN INDEPENDENT SCHOOL DISTRICT

TABLE OF CONTENTS

AS WE BEGIN

Few of us realize how short the career of what we know as "science" has been. Three hundred fifty years ago hardly anyone believed in the Copernican Planetary Theory. Optical combinations were not discovered. The circulation of blood, the weight of air, conduction of heat, the loss of motion were unknown. The common pump was unexplained. There were no clocks, no thermometers, no general idea of gravitation. The spirits moved the planet; alchemy, magic and astrology imposed action through belief or fear.

Because someone challenged those beliefs; because an organized approach to try to find out what they were going to do after they could not do what they had planned to do; we now have an impressive array of formulas, taxonomies and theoretical constructs. We have both the results of 350 years of questioning and the process by which these results have been obtained.

The essence of science is inquiry. Inquiry may be described as a structured way of asking questions and seeking their answers. Science - A Process Approach represents one effort of an experimental approach to science instruction. Such [illegible] emphasizes the students exploring his environment, the handling and manipulation of that environment. It also directs the student to explore the largely untried realm of thinking through the relating events, having ideas and testing his ideas. Exploration of the environment and thinking are extended through exploration and organizing oneself to explore, in evaluating one's deductions, in making mistakes and in improving one's approach to seeking for understanding.

Through a process approach a student is learning early to manipulate and control aspects of his environment through guided exploration.

A process approach to the teaching of science might be simply described as a student learning to do by doing. This is not quite complete. He learns by guided doing. The role of the teacher is one who structures the learning situation, one who carefully watches and listens to the learning activities, one who stimulates and encourages the learner, one who provides background and direction for the learner to skillful questioning.

Education in the sciences, as in other areas, starts where the child is. To use effectively a process approach to the teaching of science instruction, you, as the teacher, must assess where the child is and use curriculum materials to bridge the gap and extend the child's experiences in science. You must be aware of and sensitive to the thinking of children.

The Science In-Service Project is designed to explore a variety of means by which you may find assistance in sharing the joy of intellectual disc with your students, and increase their awareness of an ability to use structured ways of seeking questions and their answers.

Acknowledgement is made of the Commission on Science Education of the American Association for the Advancement of Science which sponsors the development of Science - A Process Approach, for their cooperation in permitting these materials to be used in your classroom.

The Science In-Service Project
David P. Butts, Director
Science Education Center
The University of Texas at Austin

SCHEDULE

MONDAY, JULY 15, 1968

LEAD TEACHERS:

9:00 A.M. - Overview of the Conference

10:00 A.M. - Informal discussion with coffee

10:30 A.M. - Task analysis and assignment - that is - Who will do what?

12:00 Noon - Lunch

1:15 P.M. - Review of Instructor's Guide and materials

2:15 P.M. - Self Diagnosis

4:00 P.M. - Adjourn

TUESDAY, JULY 16, 1968

LEAD TEACHERS:

9:00 A.M. - Planning an In-Service session

10:15 A.M. - Informal discussion with coffee

10:30 A.M. - Team Conference

12:00 Noon - Lunch

1:15 P.M. - Handling Teacher's Responses

2:30 P.M. - Improving Communicating Skills - the presentation of an in-service session between teams.

4:00 P.M. - Adjourn

WEDNESDAY, JULY 17, 1968

LEAD TEACHERS:

9:00 A.M. - Involvement of Teachers in In-Service - focus on sharing in-service sessions between teams.

10:15 A.M. - Informal discussion with coffee

10:30 A.M. - Team Conference and preparation

12:00 Noon - Lunch

BEGINNING OF TEACHER IN-SERVICE PROGRAM

ALL PARTICIPANTS:

1:00 P.M. - Welcome and Introduction to Science and Children - Science - A Process Approach

2:00 P.M. - Goal setting for the conference

2:20 P.M. - Informal discussion with coffee and coke

2:45 P.M. - Finding where we are

4:00 P.M. - Adjourn

THURSDAY, JULY 18, 1968

LEAD TEACHERS:

9:00 A.M. - Preparation for Low Ratio Teaching - Strategy Conference on how to present the task.

10:00 A.M. - Informal discussion with coffee

10:30 A.M. - Team Planning

12:00 Noon - Lunch

ALL PARTICIPANTS:

1:00 P.M. - Handling the Task of Deciding about Instruction

2:00 P.M. - Informal discussion with coffee and coke

2:30 P.M. - Observing, the basic stuff of science

3:30 P.M. - Structuring the Low Ratio Teaching Session

4:00 P.M. - Adjourn

FRIDAY, JULY 19, 1968

LEAD TEACHERS:

9:00 A.M. - The Two Faces of Teaching - Pre-active and Interactive. What do teachers expect of themselves?

10:00 A.M. - Informal discussion with coffee

10:30 A.M. - Team Planning

12:00 Noon - Lunch

ALL PARTICIPANTS:

1:00 P.M. - Low Ratio Teaching (Teaching - 45 minute period)

2:30 P.M. - Informal discussion with coffee and coke

3:00 P.M. - Structure of an exercise

3:30 P.M. - Feedback - does it help build up - or build down?

4:00 P.M. - Adjourn

MONDAY, JULY 22, 1968

LEAD TEACHERS:

9:00 A.M. - Handling inquiries about materials

10:00 A.M. - Informal discussion with coffee

10:30 A.M. - Team Planning

12:00 Noon - Lunch

ALL PARTICIPANTS:

1:00 P.M. - Low Ratio Teaching - Two to Two

2:30 P.M. - Informal discussion with coffee and coke

2:45 P.M. - Stating and sequencing objectives for instruction

4:00 P.M. - Adjourn

TUESDAY, JULY 23, 1968

LEAD TEACHERS:

9:00 A.M. - Demonstration classes - should we? If so, for what reason?

10:00 A.M. - Informal discussion with coffee

10:30 A.M. - Team planning

12:00 Noon - Lunch

ALL PARTICIPANTS:

1:00 P.M. - Demonstration class

1:45 P.M. - Teacher analysis

2:00 P.M. - Informal discussion with coffee and coke

2:30 P.M. - The Process of Inferring

4:00 P.M. - Adjourn

WEDNESDAY, July 24, 1968

LEAD TEACHERS:

9:00 A.M. - Conducting Awarenes... ference - Demonstration and Dis ussion

10:30 A.M. - Informal discussion with coffee

11:00 A.M. - Team Planning

12:00 Noon - Lunch

ALL PARTICIPANTS:

1:00 P.M. - Using Space/Time Relation

2:30 P.M. - Informal discussion with coffee and coke

3:00 P.M. - Constructing an Exercise

4:00 P.M. - Adjourn

THURSDAY, JULY 25, 1968

LEAD TEACHERS:

9:00 A.M. - Handling concerns of Administrators
Teachers

10:00 A.M. - Informal discussion with coffee

10:30 A.M. - Team Planning

12:00 Noon - Lunch

ALL PARTICIPANTS:

1:00 P.M. - Low Ratio Teaching

2:30 P.M. - Informal discussion with coffee and coke

3:00 P.M. - Using Numbers to Extend Observations

4:00 P.M. - Adjourn

FRIDAY, JULY 26, 1968

LEAD TEACHERS:

9:00 A.M. - Strategies in structuring an in-service program and its follow-up

10:00 A.M. - Informal discussion with coffee

10:30 A.M. - Team Planning

12:00 Noon - Lunch

ALL PARTICIPANTS:

1:00 P.M. - Low Ratio Teaching

2:30 P.M. - Informal discussion with coffee and coke

3:00 P.M. - Extending Observations through Communicating and Classifying

4:00 P.M. - Adjourn

MONDAY, JULY 29, 1968

LEAD TEACHERS:

9:00 A.M. - Review of Research Results in the implementation activities of the Science In-Service Project

10:00 A.M. - Informal discussion with coffee

10:30 A.M. - Team Planning

12:00 Noon - Lunch

ALL PARTICIPANTS:

1:00 P.M. - Demonstration

1:45 P.M. - Teacher Analysis

2:00 P.M. - Informal discussion with coffee and coke

2:30 P.M. - Quantifying Observations - or the Process of Measuring

4:00 P.M. - Adjourn

TUESDAY, JULY 30, 1968

LEAD TEACHERS:

9:00 A.M. - Current Concerns

10:00 A.M. - Informal discussion with coffee

10:30 A.M. - Team Planning

12:00 Noon - Lunch

ALL PARTICIPANTS:

1:00 P.M. - Low Ratio Teaching - with a self constructed exercise

2:00 P.M. - Informal discussion with coffee and coke

2:30 P.M. - Communicating and Predicting

4:00 P.M. - Adjourn

WEDNESDAY, JULY 31, 1968

LEAD TEACHERS:

9:00 A.M. - We look ahead!

10:00 A.M. - Informal discussion with coffee

10:30 A.M. - Team Planning

12:00 Noon - Lunch

ALL PARTICIPANTS:

1:00 P.M. - Low Ratio Teaching, with self constructed exercise

2:30 P.M. - Informal discussion with coffee and coke

3:00 P.M. - The Integrated Processes

4:00 P.M. - Adjourn

THURSDAY, AUGUST 1, 1968

LEAD TEACHERS:

9:00 A.M. - Planning Time

10:00 A.M. - Informal discussion with coffee

10:30 A.M. - Team Conference

12:00 Noon - Lunch

ALL PARTICIPANTS:

1:00 P.M. - Handling instructional decisions

2:00 P.M. - Informal discussion with coffee and coke

2:30 P.M. - Looking at our progress

4:00 P.M. - Adjourn

FRIDAY, AUGUST 2, 1968

LEAD TEACHERS:

9:00 A.M. - Revision of the in-service sessions

10:00 A.M. - Informal discussion with coffee

10:30 A.M. - Continued revision of in-service sessions

12:00 Noon - Lunch

ALL PARTICIPANTS:

1:00 P.M. - Standing on the shoulders of our experience

2:30 P.M. - Adjourn

SCIENCE AND THE CHILD

David P. Butts
Science Education Center
The University of Texas

"Class, look at this picture, and tell me what you see." said the teacher.

Hands went up, but the teacher called on Peter, whose hand had not been one of them. "Peter, what is it?"

"It looks like a rat."

The class laughed. Someone said, "Peter is so stupid. He doesn't know a rat from a rabbit."

The teacher said, "Peter, what's the matter with your eyes? Can't you see that it has long ears?"

"Yes," said Peter weakly.

"It _is_ a rabbit, isn't it, Peter?"

"Yes," he said.

"Today's story is about a rabbit," said the teacher, pointing to the picture and then the word. It's a story about a _hungry_ white rabbit. What do you suppose a rabbit eats when he's hungry?"

"Lettuce," said Mary.

"Carrots," said Suzy.

"Meat," said Peter.

The class laughed. Someone said, "Peter is so stupid. He doesn't know what rabbits eat."

"Peter, you know very well that rabbits don't eat meat," said the teacher.

"That depends on how hungry they are," said Peter. When I'm hungry, I'll eat anything my mother gives me, even when I don't like it."

"Don't argue, Peter," said the teacher. "Now, Class, how does a rabbit's fur feel when you pet him?" asked the teacher.

"Soft,"said Suzy.

"Silky," said Mary.

"I don't know," said Peter.

"Why?" asked the teacher.

"'Cause I wouldn't pet one. He might bite me and make me sick, like what happened to my little brother, the time a hungry one got on his bed when he was sleeping."

The class laughed. Someone said, "Peter is fibbing. He knows his mother doesn't allow rabbits in bed."

After the class had read the story and had their recess, the teacher said to the supervisor, "I hate to sound prejudiced, but I'm not sure that Peter's being in this class is good for the children."

The supervisor shook his head sadly and said to the teacher, "Your lesson lacked one very important ingredient."

"What was that?" asked the teacher.

"A rabbit," said the supervisor.

Learning itself can be defined as the individual merger of experience into meaning. Within this definition it is obvious that learning will not take place unless there is a learner and experience. Such an experience may or may not require the influence of a third party--the skillful guide--or teacher.

A student is engaged in an activity in the sixth grade classroom or a high school physics lab. He is gaining from his experience. But what is he gaining from that experience? What controls how much he will take from that experience?

Experience in science without the "experiencer"--the student--lacks purpose, interest, or meaning. A student without experience is unmanageable and equally lacking in purpose or meaning. To consider the role of the student in learning, the individuality of the learning experience and how it relates to both the relevance and responsibility is inescapable.

If students are to gain from their experiences in science they must link their own experiences to that in science, and they must question the relationship of their experience as a human to their experience as a student in the science laboratory or classroom. This questioning is the responsibility of the student. Learning science will be at its best when the student has the responsibility to initiate action, and the responsibility to interpret the results of his science experience. With this expanded freedom for initiation or interpretation the student becomes less dependent upon the teacher. He has a greater insight into both the question and the answer he seeks because he identified it.

From another viewpoint, learning can also be an event analogous to a collision between the student and the structure of a subject. This collision will have its greatest impact when there is a readiness on the part of the student for the subject matter. As the engineer of the collision--the teacher assists in identifying the student's readiness or the inventory of the student's past experiences that are relevant to the structure of science.

To engineer this collision, should the teacher organize the experience in science to fit the student or should the student be made to fit the experience in science?

If the student's past experience limits the extent to which the present experience will be meaningful, then in order for learning to occur, the student must:

1. have a meaningful goal, a question or frame of reference to guide his activity;
2. have a desire to act;
3. have the means by which he can act, that is, a set of skills by which he can process the information of his experience in a meaningful interpretation.

The challenge here is a search for those experiences that provide the student with success related to desire, a foundation of knowledge out of which comes the frame of reference upon which to base both questions and their answers, and the skills to process information into meaning.

Relevance and responsibility in his encounter with reality are inescapable requirements for learning in science. The smaller the base of experience the shorter the time the student can accept the responsibility for directing his own actions. The challenge here is to provide a sequence of experiences that will enable the student to enlarge his base of knowledge thus enhance the <u>relevancy</u> of new experiences and his skills to process the data and thus enhance his ability to accept the <u>responsibility</u> for initiating action and interpreting its results.

If the experience is appropriate, the student will both find it relevant and himself capable to act on it. If the student does not find the experience relevant, or if the student is not capable of acting on it, then the appropriateness of this experience must be questioned.

There are occasions when more than just the experience and the student are combined. Additional components are needed to enhance meaning through the skillful structuring of the situation. These components describe what the teacher provides in structuring the student's experience.

The best learning situations usually occur when there is an appropriate mixture of students and teacher. The student is a star. It is he upon which the action and the spotlight is focused. As the star of the production, the student must have a stage upon which to operate. Selecting this stage, setting it up with desirable materials and making sure it fits the student's needs are significant contributions to the teacher.

Getting started with the production may represent another point where the students will need assistance. As a director of a theatrical production recognizes that each star is an individual capable of deep, rich and meaningful experience, he carefully listens during informal rehearsals. He observes mannerisms, voice inflections, superficial role interpretations, and other key behaviors. Then the director selects appropriate means by which to help the star improve his performance. He recognizes that "telling" the star that his gesture was inappropriate will not do the job. Rather with the star, the director actually explores and practices better ways to move the hands.

In a similar role the student is observed by the teacher-director. Those areas in which the student needs assistance are identified by starting with a situation in which the student must perform the specific behaviors described in the objectives of the experience. Through watching, listening, and a variety of observations, experiences,that each student needs,are selected.

The need may be the use of a poor inference, inability to express himself, or the lack of skill in manipulating apparatus. All students will not have the <u>same need</u>, but each student will have <u>some need</u>. The learning situation is the tool for diagnosing the students "experience-relevancy" and his "responsibility capacity."

If the student is to gain meaning from a new experience, he may need some additional assistance from the director-teacher. Just as a director finds "telling" a rather limited value, so do teachers in the classroom. The "telling" approach to teaching began in the Medieval Ages when there were no sources of information other than the teacher. There are many sources for student's experiences today. These range from the aquarium in the first grade classroom to the pressure chamber in the high school laboratory. Involving students with these resources so that they are the star performer is a real challenge. This challenge can result in rewarding success if the students' responses are handled in such a way that he gains a new respect for his own ability to deal with the situation. Within the context provided by skillful teacher-director the student initiates action and accepts responsibility for his action. He explores his environment--he handles and manipulates it. He also explores the largely untried realm of thinking through relating events of his experience, having ideas about these events, and testing these ideas. Exploration of his environment and thinking are extended through his organizing himself to explore. This is accomplished through evaluating his own deductions, through making mistakes, through inproving his approach to the seeking for understanding. In this way the students' role is one of learning to manipulate and control his environment through guided exploration.

Such approach might be described as simply the student learns to do by doing. This is not quite complete. The student learns to do by guided doing. The teacher is the one who structures the learning situation, the one who carefully watches and listens to learning activities, the one who stimulates and encourages the learner, and the one who provides the background and the direction for the learner, through skillful questioning.

SUMMARY OF CHALLENGE

Renewed interest in students and science has returned us to a basic premise. Learning will be at its best when the relevance of experience is apparent to the student because he has had the responsibility for initiating action and interpreting his own experience. The persistent challenge is how to structure the learning encounter so that gaps in the students' experience will be closed.

Meeting the Challenge -- Instructional Objectives

One aspect in meeting the challenge of structuring student experiences is to examine the statement of instructional goals. If these are stated in terms of what the student should be able to do by the end of the instructional experience, there is a far greater probability that relevance and responsibility for learning will exist.

Objectives stated in vague terms--such as the student is to gain an understanding, or to increase in his ability in critical thinking, or to understand important relations in science describe the important outcomes. Yet, as stated, these objectives are of questionable value as guides for instruction. They limit the study to science but they certainly do not provide any direction as to <u>what</u> within science one <u>might expect to see student's doing</u>.

If objectives are to be useful in structural experience, they must reflect some specific outcomes of that experience. For example, with the objective the student is to gain an understanding of major science concepts. What does the word "understand" mean? Does it mean that the student should be able to use the concepts in some situation? If so, how and when are these to be used? What specific tasks should the student be able to do? What is the specific situation in which the student should be able to accomplish these tasks? How would the teacher determine whether or not the student had succeeded in accomplishing that specific objective?

If an objective is to result in student centered experience, it must be stated in terms of the specific behavior of the student that can be observed by the teacher. Only then will the objective provide direction for both the learning experience and the appraisal of the effectiveness of that learning experience.

The initial writing of instructional objectives in terms of what the student will be able to do may sometimes be difficult. With experience this task becomes more manageable. The process follows a simple pattern consisting of three considerations:

1. identification of the behavior desired;
2. description of the situation and instrument in which the behavior is to be observed;
3. description of the extent to which the student should exhibit the behavior.

The most effective behavioral objectives are those which reflect all three of these criteria.

The behavior which is expected to be observed is indicated by the verb denoting the action. Teachers cannot observe "knowing," "understanding," or "appreciating." They can, however, observe a student who is "constructing," "choosing," "writing," and "describing."

If the student behavior is to be observed, then the teacher must decide where one is to look for that behavior. If the teacher expects students to identify constellations, then those situations should be specified in which the student will accomplish this task. For example, will the student work with photographs, drawings of the sky, separate drawings of each constellation, or observation of the sky at night? It is quite possible that the teacher would consider all of these situations, some of them, or situations which have not been mentioned. Unless the situation is determined and described, the objective could lead to many interpretations and hence would not give the specific direction which is essential for the objective to be an effective guide for instruction. Statement of objectives assumes sifnificance because they allow the teacher to determine the success of the instructional experience.

Instruction can be readily evaluated if the extent of the behavior becomes part of each objective. For some objectives the students will or will not be able to perform the tasks, but for many tasks it is necessary to determine a degree of success. If, for example, an objective was "the student should be able to write the definition of osmosis", then the experience has been successful if the student can accomplish this task, and unsuccessful if he cannot. With an objective stated in this way, there is no measure of partial success. On the other hand, if that objective were modified to read "the student will be able to identify and write the names of constellations from a drawing of the sky", how does the teacher determine success? This situation is such that it will be necessary to decide which constellations, and a fraction of these constellations, a student is to identify in order for his behavior to be accepted as successful.

Properly worded instructional objectives, therefore, include a description of the behavior, a description of the situation, and the extent of the behavior which is expected. The situation and extent of behavior may be implied in the statement of the behavior, but if not clearly implied, it needs to be specifically stated.

Meeting the Challenge -- Student Involvement

Recognizing that experience is a pre-requisite of development of both knowledge and skills, the structure of that experience becomes a significant factor in science instruction. To meet this challenge, students must be made to feel that they are studying something of value and not merely executing intellectual minuets. They must actively do something with material in carrying out <u>their own</u> action and then have reason to stop and examine the <u>results</u> of their action. This means designing curriculum materials in which the student's experience is a personal thing stimulated from direct observation of an event which leads to inferences about relationships and the testing of these inferences. This design is in contrast to the student solving a puzzle that is imposed upon him by the teacher and that solution has for its main reward the seeking of completing an external requirement. Only by the opportunity to seek and find his way out will a student experience both relevance and self directed responsibility.

A specific contrast in examples might be useful. In a classroom in grade five of a well designed and well equipped elementary school, the teacher was ready to begin a unit on "Rocks". She started with the announcement that the students are going to begin a unit on "Rocks". The teacher then spent several minutes describing to the students why it is important for them to make a study of rocks and how much fun it will be; she also added that the next day they would set up the objectives of the study. In the meantime, the students were to think about questions about rocks. The next day in class the students agreed upon a list of objectives for the unit and questions that they wished to answer. Curiously enough the questions and objectives corresponded very closely to the information the teacher gave the previous day. The teacher then announced a series of activities that the class would undertake in the study of rocks. These activities proceeded in a systematic way. Committees were formed for each major heading of questions. References from the library for each committee were suggested. As the committees began work, the teacher brought supplementary materials--reading materials and charts from her vertical files. She gave specific instructions on how each committee report should be written and illustrated, and saw that the committees were at work. Many of the activities included the activities of textbooks and tradebook references. No attention was given to the accuracy of these books. The assumption was explicit--if it is printed in a book, it must be true. To one group the teacher suggested a film on volcanoes. To another group, the teacher suggested a local geologist who could talk about rocks found in the community. Both of these events were scheduled and enjoyed by the entire class. Some vocabulary words related to rocks were studied. During the month the unit was in progress, daily filling in of the "rock science notebook" laboriously dragged on. By the end of the unit--the end of the month--the students were restless and ready for a change. The teacher realized that the students had lost interest, but was faced with another dilemma, should she stop the unit or let the last three committees make their report? Obviously, something needed to be done. She met with the three committee chairmen and suggested that they make only five minute summary reports, rather than the entire committee report. Not knowing how to proceed, they appealed to her for help and she wrote out the brief summary for each of them to read. She then decided to end the unit with a class evaluation. In this evaluation the students agreed that they had learned how to classify rocks according to sedimentary, igneous, or metamorphic· to recognize a volcano; and expected to continue their interest in rocks.

The teacher announced that it was time to move on to the next unit which would be on the solar system and space.

Another teacher started a unit on rocks also. Her goal was not only for students to acquire some knowledge about rocks, but develop some skills in classifying objects according to a predetermined system. From her past experience,she knew that students believe that anything in print was true. They had probably developed such a belief because most of their educational experience had been rooted in the printed page. She had heard several of them say, "I can prove it, because I read it in . . ." This teacher could have told the students the strength and weaknesses of textbooks and library books, but she also knew that learning comes from within, not from without, and that students are more apt to use knowledge gained through self initiation and self directed responsible action. For this reason, she started the unit by presenting the class with a collection of rocks. Their task was to arrange these rocks into three groups, and describe to her their system of classification. Initially, some members of the class suggested that they use the three types of tocks: sedimentary, igneous, and metamorphic. The class agreed to use those three categories and immediately started to group the rocks. Almost as quickly, the students stopped. Before grouping into these three categories, they needed clear cut criteria for each category. To manage this concern, the class decided to assemble the committees to do library "research" in the characteristics of these three types of rocks. Then they were to select those rocks of the sample that "fitted" each category. Within two days, consternation developed. There were several rocks "claimed" by each of the three groups, when they used the criteria described in text and other reference materials. How could they resolve this problem?

By this time, the students were genuinely puzzled over the discrepancies and differences in the books. The teacher let them rangle over these discrepancies in the class discussion. She allowed them to come face to face with the felt difficulty and problem. Then she interrupted the discussion with the inquiry as to what it was they wanted to know. What was the definition of their ideas until they had finally resolved the question to this: "Experts--that is geologists or scientists--classify rocks, but how do they do it?" Their plan of action was to secure help from a geologist in creating the classification procedure. Through this attack they discovered that the means whereby rocks are classified is quite different from the means whereby the three types of rocks are usually described. Specifically, classification of rocks requires the use of a variety of tests and observational data rather than one or two characteristics. With this cue, the students gathered information about the observable characteristics of rocks. They gathered rocks and tried these tests on those and created their own classification system.

Such an approach meant that the students were the stars in actively seeking questions and their answers. Note that this is quite in contrast with the self contained science unit on rocks whereby the students were spoon-fed information from a single text or a variety of resources that the teacher had brought in for the students to use. The latter approach involves students actively seeking knowledge--makes them the creator of their <u>own</u> textbooks as they synthesize the interpretation of <u>their own</u> experience.

ON LEARNING SCIENCE

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Should I use this experiment?

What about that bulletin board?

Which Text best suits my situation?

Is that book accurate?

Did they have the same experience in the third grade?

What units do I teach this year?

These are all questions of what and how which demand a group of whys to serve as criteria for answers.

Why use this experience?

Why use this book?

Why teach this science unit?

Eventually these questions resolve to the question of why have a science sequence or why teach science.

To describe a curriculum sequence, we first start with a stipulation of the goals or directions for this sequence. What are the goal or goals of science instruction?

Probably, a better question might be asked, what are the general goals for education, and how does science instruction relate into these goals? Woodruff, among others, has proposed that the goals of education may be summed up as providing experiences for children which will enable them to make wise choices and worthy decisions. Wise choices necessarily involve knowledge and the ability to use that knowledge. Worthy decisions involve the knowledge and its use with an added ingredient, a sense of values. While not ignoring the desired values of our society, the domain best served by science instruction is that of knowledge acquisition and its use--or the practice and understanding of science.

Agreement on a broad objective for education or even on a more specific objective for Science Education--the practice and understanding of science--still leaves to be resolved how these objectives relate to the classroom experience of a fifth grade class.

Preparing and teaching science not only requires goals, it requires the selection of the content, the design of the experiences and the recognition and analysis of the impact of the combined content and experiences. Preparing and teaching requires that optimum learning conditions be present. Watson and Cooley described learning as:

> The readiness of each individual pupil and the structure of the subject come together in the process we call "learning". Teaching is then a procedure by which we attempt to expedite or catalize this learning.

Involved in the act of learning are three specific factors:

1) The structure of a subject--or the content which is selected;
2) The engineered collisions between the student and the subject--or the designed experiences;
3) The readiness of the student as illustrated by effectiveness of the impact or the receptivity of the student.

The next three sections of this paper will review each of these three components of the learning "collisions" as they are specifically related to science education.

THE STRUCTURE OF SCIENCE OR THE CONTENT TO BE LEARNED

Each student's success in achieving his desires and abilities to make contributions to the good of others depends on how well he finds out how the world works and how well he learns to get along with that world. While the practice and understanding of science can make a significant contribution toward that goal, unanswered is the question of what understanding of science, and how do you translate this goal into a sequence of experience which will result in successful "collisions?"

A study of man's progress reveals that his greatest advances have occurred through a sequence of successful solutions to problem situations. Dewey recognized that learning results from doing. One reason for the lack of success of the rote learning of science content is the lack of the involvement of the student. Problem-solving offers an excellent solution to this. From the science content which is selected because of its appropriateness to the problem situation, the main impact on the student would be a broad generalized ability to cope with any environment.

Selection of content for problem situations would result in the student's having both the content and the generalized approach to any problem from the student's own involvement and doing. However, selection of content directed toward a general problem-solving ability lacks the evidence that such an ability does indeed develop to the extent that it is transferable to new situations. Psychologists, as exemplified by Gagné, suggest that such an approach is too narrow and too exclusive in terms of student experience. Cronbach suggests that a curriculum built around applications of science in problem situations give a false picture of science or possibly no picture at all.

Thus, selection of content in science in terms of a problem approach results not in the practice and understanding of science, but in a limited and narrow practice of an approach to problem-solving with little or no understanding of science itself.

Bruner points out that to know the structure of a subject is to know its patterns and concepts. To deal with the fundamental structure of a field makes that subject understandable and facilitates transfer and usefulness of that which is learned. Bruner more recently suggested that discovery which is grounded in one's having prior knowledge to use, involves the individual in rearranging data in ways which will permit him to go beyond that data to a new understanding. Conant's description of science is:

> Science emerges from the other progressive activities of man to the extent that new concepts are formed from experiments and observations and the new concepts in turn lead to further experiments and observations...this dynamic quality in science is viewed not as a practical undertaking, but as development of conceptual schemes.

Foshay seems to relate to these conceptual schemes described by Conant to the structure described by Bruner and adds a second ingredient. He asserts that each discipline is characterized by its domain---or conceptual scheme of structure and its way of knowing or method of inquiry. Schwab relates the structure to inquiry in that he defines the structure or science as those concepts which define the domain of the discipline and determine its inquiry.

Clearly the understanding of science stands out as one of the desired goals of the teaching of science. A second side of science seems to have been identified by Foshay and Schwab. The conceptual schemes, structure or domain of the discipline are incomplete. These conceptual schemes must be ordered or arranged. Mach very cogently described <u>this</u> ordering of arranging as:

> When experience has once clearly exhibited these facts and science has marshalled them into economic and perspicuous order, there is no doubt we shall understand them. Before our "understanding" them, a mental mastery of facts never exists. Science does not create from facts, but it simply orders known facts.

While the relationship between the domain and its way of knowing is described by Bruner and Schwab, we lack full agreement on what "way of knowing" really means. To some it is called problem solving and investigated as a general procedure applicable to all situations. However, might a more accurate and efficient view of problem solving be what one does when one brings to a problem patterns of ideas and inquiry methods specific to particular disciplines? Thus the two sides of the proverbail coin seem to be inseparable. If the practice of science and the understanding of science are so closely related to the scientific enterprise, then here logically are the goals of science education.

Selection of content in terms of the structure of science results in the student practicing and understanding science as the structure of science demands. However, in reference to the conceptual schemes, Schwab questions if they may not merely become another series of intellectual tidbits to be examined and ingested. Gagné suggests that these conceptual schemes may become things and not abstractions or hypotheses about observable phenomena which should be subject to empirical test. Cronbach relates inquiry to the conceptual schemes by saying:

> The mathematician is saying that he cares little about what mathematical topics are studied, that what counts is how much the student learns about the nature of mathematical thought. In physics, what matters is not how much or how many physical laws are learned, but how what the student

knows is organized. The student is introduced to the tools of a discipline rather than to its products.

Schwab also suggests that in the classroom, the student may only see the conclusions of inquiry. These he may identify as facts--and quite possibly as isolated facts. The cohesion and organization of these facts is usually underemphasized or omitted. The student sees little and understands less of the constituents of inquiry, that is, the organizing principles, the data, the interpretation of the data and the competencies needed. Is it possible that practicing inquiry without an adequate background of knowledge can have little impact on the student's intellectual development? Might it even have a side effect of limiting his ability to think independently? Suchman and his experimental data indicates that it was evident that the student needed more than a way, a strategy, in which to think. The concepts of the students were inadequate both in terms of breadth and depth. Are there some specific requirements before a person can be independent in his thinking? If so, what are they and how can they be developed?

Selection of content in terms of the structure of a discipline may result in the practice and understanding of science, but may more likely result in an extremely limited and cramped practice and understanding of science. Does this mean that this is not a suitable or feasible goal? Or is this goal best examined not from the standpoint of a teaching goal, but from the standpoint of pupil behavior? If a person is practicing and understanding science, what will he do?

The practice and understanding of science is best illustrated by the individual capable of autonomy in his investigation. Just what content is necessary to make the student capable of this autonomy is not easy to identify.

Regardless of this difficulty, the content must be identified if the goal is to be achieved. To do this Gagné suggests that first we need to identify the terminal behavior, that is, that student behavior that best describes our goal. In a general way this means that if the student practices and understands science, if he has the desired autonomy in a problem situation, he will:

1) Begin with a set of systematic observations;
2) He will design measurements that are necessary to quantify his observations;
3) He will distinguish between what he observes and what he infers from what he observes;
4) He will invent interpretations;
5) He will draw reasonable and possible creative conclusions from his observation and analysis.

These five behaviors describe the advanced level of behavior which characterize the autonomous investigator. What is needed to develop these types of responses to problem situations? Careful analysis of an investigative act suggests that there are several competencies demanded if the investigator is to be successful. These competencies include the ability to observe, to quantify his observations and to infer from the data of experience. In order for the student to observe, quantify on infer, he must have developed from a broad experience in many diverse situations the specific abilities to observe likenesses and differences in objects, to measure, to quantify his measurement, to orient objects and events in space and time, to describe, to classify objects and events, to communicate, to predict and to infer. Content selected to assist the student acquire these competencies might be considered one level of development--that of the <u>manipulator</u> in which specific competencies are developed.

An efficient investigator needs competencies of another level. Ability to handle the objects and events of his environment does not in itself make a student an investigator. He must be able to define what about a situation needs to be investigated. He must be able to analyze the situation to determine what objects and interactions are present, and through verification activities using careful controls assess the specific contribution of each object to the interaction. He must be able to build a model or hypotheses of the reason of these interactions, and experiment with this model in many different situations to ascertain its accuracy, adequacy and completeness. Development of these competencies necessarily involves the student acquiring a broad base of knowledge of the principles of science. This broad base of knowledge represents not so much the science content covered, but must be the organizing principles in the student's thinking around which he can direct his activity.

Selecting content for this level of development may be accomplished by further analysis of the inferential and mental model building in science. Content which illustrates both these aspects as well as an acceptable statement of the major themes of science represents the direction of this level of competency building. Just as the best way to study a musical masterpiece is not to isolate the notes of different values on separate sheets, the broad base of knowledge is established best when those conceptual schemes that permeate all of the scientific endeavor are seen by the student in a wide variety of situations. Thus at this level content is selected to permit the student to see each theme in many different circumstances. However, just as important, the presence of the theme must be discovered by the student from his experience in the instructional situation and not from a didactic presentation of the theme.

Do competencies in dealing with objects and events in the environment, and organizing principles as a part of the broad base knowledge in addition to the competencies in identifying and verifying relationships of the environment represent the complete picture of the needed abilities in order to be autonomous in an investigation?

One other competency needs to be added--the strategy of asking productive questions. How a student may structure his question asking is a behavior which can be acquired. Using the broad base of knowledge as a general direction, and the competencies of identifying and verifying relationships in the environment as a procedure, the student needs to learn how to give specific direction to his thinking. He needs practice--and a great deal of this practice--in asking questions and in considering the probability of being able to find satisfactory answers to these questions. More specifically, he needs to seek creative connections between the objects and events of his experience and he needs also to carefully evaluate these suggested connections in terms of the broad base knowledge and the plausibleness of the ideas. At this level, content is selected which will assist the student in further broadening his base of knowledge while offering him ample opportunity to acquire and practice a strategy of inductive reasoning. The latter may be described as the <u>incisive knowledge</u> necessary for the investigator if he is to be successful in his resolution of a problem situation.

Development of a broad base of knowledge from related understandings which themselves are dependent on competencies in handling and interpreting the environment represents two levels of science content. Adding a third, the sharpening of a strategy of search for new connections in using this broad base of knowledge, we may have a picture of those behaviors needed for a student to be successful in solving a problem situation in science. The student has the necessary competencies to assume full responsibility of a science investigation which may be described as:

1) He depends on himself;
2) He trusts himself;
3) He looks at problems objectively;
4) He has new ideas; and
5) He judges those new ideas critically.

Content is selected which will assist the student in operating at the advanced level of the terminal behavior of the practice and understanding of science: The student uses the approach of inquiry toward the solution of problems.

What specific content should be selected depends on a detailed description of the competencies needed by the manipulator level, a delineation of the conceptual themes and the advanced level competencies which comprise the broad base of knowledge, the connector level and an identification of the appropriate search strategies or incisive knowledge which are the patterns of concepts that the student used to direct his thinking in a specific science discipline and to help him evaluate the appropriateness of his questions or inquiry. This is the questioner level.

Beyond the identification of this content remains an extremely crucial question - how are the experiences of the student structured to insure the best impact of the learning collision? Should the student study the specific conceptual themes? Should the student's understanding of these themes come from his experience? How often must the student come in contact with the themes for them to be part of his base of knowledge? If the student is not given the themes, will he form them automatically from his experience?

We now turn to examine the second factor of the learning situation... the design of experiences.

THE ENGINEERED COLLISIONS BETWEEN THE STUDENT AND THE SUBJECT, OR THE DESIGNED EXPERIENCES

The verbal extrapolation or analysis of relationships of phenomena in their environment required that students must:

1) Observe the phenomena with great care;

2) Relate their observations to previous experiences;

and

3) Interpret the present situation within the framework of their previous experiences and through this interpretation initiate an analysis of the event.

Thus the design of experiences for the student that will maximize the impact of the collision as engineered by the teacher must be predicated on an analysis of the student himself. The student's past experiences will determine the extent to which the present experiences are meaningful. The appropriateness of the student's present experience might be illustrated by this description of a classroom situation:

CLASSROOM SITUATION	RELATED OBSERVATIONS
The subject under study was the formation of clouds.	
Question: How do clouds form?	Good question
Question: Do they form like dew only in the air?	What previous experience must the child have had in order for this question to be meaningful to him, in order for him to have asked this question?

CLASSROOM SITUATION	RELATED OBSERVATIONS
Question: What conditions would we need to have a cloud?	Previous experience with "a cloud" knowledge must be utilized here if this question is to be meaningful.
Statement: Therefore, if a cloud forms mist like dew, then we should be able to make one in a bottle.	A conclusion - dew forms in a bottle -- which is stated and then the proposal is made to verify it. What previous experience is necessary with dew and bottles for this to be meaningful to the student--i.e. under what conditions does dew form in a bottle? What is dew?
Direction: Then let's do the following	
1) Fill a jug with moist air.	What previous manipulative experience is necessary to know how to fill a jug with moist air? What knowledge background is necessary to determine that moist air is needed?
2) Add a little water and then place some dust in a jug by inverting it and adding a little smoke from a burning match.	Why add water? What previous experience indicates that smoke is dust?
3) Finally we can warm it (the air in the bottle) by blowing in,	Why should we need to warm the air? Why does blowing in the bottle warm it? The previous experience with the idea of warming by compression is assumed.
4) and cool it (the air in the bottle) by letting the air come out.	Why cool the air; Where in the student's experiences does either warming or cooling enter into the situation? Why does letting the air come out cool it? The previous experience with cooling by expansion is assumed.
Conclusion: The result of such an experiment as this can help a very young student explain for himself a natural phenomena, how clouds form.	Does it?

The purpose of the analysis of the student's previous experiences is to identify to what extent the present experiences will be meaningful to the student.

For the student to analyze the relationship in an event he must be able to interpret this event in terms of some reasonable framework of past experience. Interpretation demands that the present event be compared with other similar events and that similar and dissimilar aspects of these events be identified in an effort to discover the exact relationship involved in the present experience. In order to make the comparison with other similar events, the student must have had an adequate base of experience to have recognized and categorized several events as similar. He then can use the basis of the categorization as a directional or organizing principle in his interpretation of the present event. Before events may be recognized and categorized as similar, they must have been experienced--observed and the observations must have been done with sufficient attention to the detail of the events.

Thus in order for the experience of analysis of cloud formation to have been meaningful for the student, there are three levels of previous experience needed:

1) Direct experience with the specific objects of the environment. This must be a broad range of experience in learning from observation and manipulation of the environment. Meaning grows from first-hand experiences, that is, the meaning which is best characterized as the what of the environment.

2) Indirect or Semi-Concrete Experience with vicarious aspects of the environment. The student is able to find indirect experiences meaningful if the base of direct experiences have been adequate. He can use indirect experiences as a way of extending the base of observational meanings and as a way to begin to recognize similarities or specific categories of experiences. Thus indirect experiences extend

to the meaning of the _what_ and initiates the _how_ relationships of the environment.

3) _Interpretative experience_ in which the student recognizes similarities or categories of past experience. These categories are sharpened so that they become functional organizing directions for the student's reasoning. This represents an extension of the _how_ relationships of the environment and the initiation of the _why_ relationships.

4) _Verbal analysis of relationships_ in which the what, how and why of the environment are meaningful to the student in that he can manipulate symbols for these past experiences and do so with intelligent reasoning.

The collisions which are engineered for highest impact are those to which the student can bring meaning from his past experience. Identified are four levels of this past experience to which the student can bring meaning: _Direct_, _indirect_, _interpretative_, and _verbal_.

These four levels represent a hierarchy of meaning for the student. The way which teachers have found most successful for students to learn is to engineer the experiences of these students in terms of the students themselves, i.e., to analyze what previous experiences the students have had and build from that point.

RECEPTIVITY OF THE STUDENT TO THE EXPERIENCE

Our attention must necessarily again focus on the object of this collision--the learner. Given the sequence of content and the best design of the experiences, will he learn? What factors affect the receptivity of the student in the learning situation? A better phrased question might be, how does the sequence of designed experiences relate to the student's achievement?

Psychologists have been investigating this question for some time. Little direct evidence can be cited concerning how children learn science. From related studies, certain general guidelines can be elucidated however.

One group of studies in psychology seems to indicate that if a child is not ready to learn, he will not learn. Specific factors that affect the child's readiness to learn are the relevance of the experience and his past experience, the relevance of the experience and his interests, and the relevance of the experience and the student's vocabulary. Cronbach suggests that for students with poor vocabularies and poor conceptual development, readiness must be developed by a painstaking design of ideas. The readiness of the child for the collision may thus affect the impact of that experience for him.

Another factor related to the impact of the collision is the motivation of the child. Blair has suggested that without motivation there can be no learning. Specific factors related to the motivation of the student are his needs. These needs have been variously described as recognition, security, response, new experience, achievement, status, and affection. White has added a new need. He identifies specific instances of motivation which do not seem to be explained by the above needs but which seem to be best described as a need for competency in dealing with the environment.

Piaget has suggested an equilibrium theory that may relate both readiness and motivation to a single scheme. He describes an equilibrium theory of behavior as a child stays at a level of reasoning until he cannot handle it conveniently. What was equilibrium (in handling his experience) becomes disequilibrium so he shifts to the next level. For the child within the school years, his reasoning is characterized by manipulation with those objects in his immediate environment. Equilibrium exists as long as he can conveniently handle these in his thinking. When these objects become too many, disequilibrium sets in and the child shifts to the next level, from concrete operational to concrete logical. At the concrete logical level, the child is no longer dealing with just objects, but with specific connections between these objects. He establishes a universe of relations within which he can conveniently handle his environment. He has identified simple patterns in his perceptions of the environment.

However, when the universe of relations become more than convenience permits him to handle, disequilibrium sets in and the child shifts to the next level, abstract operational. At this level, the child initiates a higher level grouping of his experience or shifts the universe of relations into a universe of classes. He has identified sharper patterns in his perceptions and is beginning to identify patterns in these patterns or patterns between concepts. These patterns between concepts are the genesis of the organizing principles which he can use to interpret his environment. At this level, the child seems to acquire a reverse gear in his thinking, i.e., he can go from the experience to the abstraction about the experience or from the abstraction to the experience.

When the conceptual framework of the student becomes developed to the point that he no longer can conveniently handle them, he shifts to a fourth level, abstract logical. At this level, he identifies specific patterns between concepts or conceptual schemes. These may be described as a universe of causes. The child is now able to reason in abstractions totally.

Summarized, the equilibrium theory of Piaget may be pictured as:

Conceptual Scheme	Universe of Causes	Abstract Logical
More complete		
Simple		
Concepts	Universe of Classes	Abstract Operational
	Simple Concept Patterns	
Perception	Universe of Relations	Concrete Logical
	(Simple Perception Patterns)	
Data	Universe of Substances	Concrete Operational

Organization Transferability

A further scan of research evidence from the psychologist indicates that:

1) Learning is a relatively permanent behavior change which is the result of experience.

2) The factors of the child's attention to the experience and his strategy of operating within the experience helps determine his resistance to the stimuli of experience.

3) Extremely important to the learning in a situation are the breadth or narrowness of the child's use of the available clues and his success in solving the problem and his learning the significance of views other than those directly related to the solution.

4) A high drive or over learning reduces the student's ability to pick up incidental clues.

5) Satisfaction which some children obtain from manipulation and mastery of their environment is highly important.

6) As children grow older, their acceptance of a challenge in a task grows.

7) Superior discrimination learning is generally associated with greater scanning of stimuli--a greater attention to detail.

8) As children grow older, they become more persistent in their attempts to find the way to beat the game--they increase their search for patterns and order.

This seems to say to us that a child's reception to any learning experience changes as his experience and cognitive style shifts. Thus it may be that within a specific learning situation, the child's receptivity described in terms of his readiness or motivation is really a function of his past experience and his cognitive style. Related to Piaget's equilibrium theory, the cognitive style itself is related to the breadth and level of the child's past experience.

SUMMARY

In this analysis of science curriculum, the practice and understanding of science has been identified as the goal. The description of this goal in terms of student behavior by the scientist indicates that the student should use the approach of inquiry to solve problems. The experiences necessary for the student to use the approach of inquiry includes competencies in dealing with the environment, competence in dealing with a broad base of knowledge about the environment, competence in questioning the experience of the environment. Achievement of the ultimate behavior is predicated on a series of selected competencies--<u>manipulative</u>, <u>connective</u>, <u>questioner</u> and <u>investigative</u>.

From the teacher, successful experiences are those to which the student brings and takes meaning. For this reason, experiences that call for verbal analysis must be preceded by interpretative experiences. Interpretative experiences must be based on a broad base of meanings developed from direct experiences which may be extended through indirect experiences. Meaning in a specific experience is predicated on the previous experiences of the student--direct, indirect, interpretative, and verbal analysis.

The psychologist has described the receptivity of the student to an experience in terms of the cognitive style of that student and his past experience. The student's cognitive style seems to shift when it becomes inconvenient for the student to handle his experiences or their interpretations. The shift from concrete to abstract reasoning thus can be identified. That shifts in the student's cognitive style do occur is clear. The relationship between these shifts and the student's past experiences a seems quite clear. The psychologist identifies four shifts in cognitive style: concrete operational, concrete logical, abstract operational, abstract logical.

Are these three groups of individuals, the scientist, the teacher and the psychologist, all describing the same thing, or aspects of the same development? Past experience is certainly most important to the structure for selecting content as identified by the scientist; for the design of experiences for meaning as described by the teacher; and for the shift in cognitive style as delineated by the psychologist. Are they all talking about three sides of a pyramid? If so, does this offer us some useful guidelines by which to answer the questions raised at the beginning of this discussion?

Do we have a basis for selecting the experiences for children, including books?

Do we have the criteria for selecting content?

Do we have the criteria for selecting the desired student behaviors?

Do we have the criteria for evaluating student achievement?

ROSTER

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5th Science Conference

for Teachers using

A Process Approach to

Elementary School Science

ROSTER

(4th Revised Copy)

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APPENDIX B

CONFERENCE EVALUATION FORMS

Team ______________________

OPERATION T BLAST

We need your help in thinking back over this conference. The following is a list of the sessions in this conference. Some of the sessions you have found more useful in serving your needs as a T_2 or T_3 than have been other sessions of the conference.

1. Please rank the sessions from #1 the most useful to me to #19 the least useful to me.

Rank of Usefulness

_____ a. Overview of Conference

_____ b. Review of Instructor's Guide and Resource Material

_____ c. Pre-Post Testing

_____ d. Fishbowl on Planning an Inservice Session

_____ e. Team Level Conference

_____ f. Role Playing of Film and Feedback

_____ g. Presentation of Observing Session (Mrs. Howell)

_____ h. Presenting Sessions to T_1s

_____ i. Fishbowl on How to Structure the Situation for Low Ratio Teaching

_____ j. Analysis of Structure of Inservice Programs - Preactive and Interactive Phases

_____ k. Participation in Low Ratio Teaching

_____ l. Constructing an Exercise

_____ m. Analysis on Why Have Demonstration Classes

_____ n. Fishbowl on Planning an Awareness Conference

_____ o. Handling Questions of School Administrators and Supervisors

_____ p. Analysis of Equipment and Prices

_____ q. Review of Research Results

_____ r. The Patterns and Content of Inservice Programs

_____ s. Organizing the Structure of an Inservice Program

2. Please state your reason for Choice #1.

   Please state your reason for Choice #2.

   Please state your reason for Choice #18.

   Please state your reason for Choice #19.

3. Please suggest an alternative activity for the time spent in #18.

   Please suggest an alternative activity for the time spent in #19.

4. What other comments or feedback would you like to make?

Team ____________________

Instructions: In a manner similar to your response to items on the Semantic form you filled out earlier, we would like your frank, anonymous evaluation of each session you participated in during this workshop.

To the right of each session title encircle the name of your instructor for that session. Then mark the seven point rating scale located between the two polar words, "Weak" and "Strong," based on your feeling or evaluation of each session.

In addition, please add any additional feedback comments in the space provided.

Section One - Process Sessions

1. Observing Session Instructors:_______________

Weak..Strong
Comments:

2. Behavioral Objectives Session Instructors:_______________

Weak..Strong
Comments:

3. Feedback Session (with film and role playing) Instructors:_______________

Weak..Strong
Comments:

4. Inferring Session Instructors:_______________

Weak..Strong
Comments:

5. Using Space/Time Session Instructors:_______________

Weak..Strong
Comments:

6. Using Numbers Session Instructor :______________

Weak...Strong
Comments:

7. Communicating/Classifying Session Instructors:______________

Weak...Strong
Comments:

8. Communicating and Predicting Instructors:______________

Weak...Strong
Comments:

9. Measuring Instructors:______________

Weak...Strong
Comments:

Section Two - Teacher Action Sessions

1. One-to-One Teaching

Weak...Strong
Comments:

2. One-to-Two Teaching

Weak...Strong
Comments:

3. Feedback with Partners

Weak...Strong
Comments:

4. Constructing an Exercise

Weak..Strong
Comments:

Section Three - Special Sessions

1. Teaching Demonstrations a. Teacher ____________________

Weak..Strong

b. Teacher ____________________

Weak..Strong

Special: Overall Workshop

Weak..Strong
Comments:

Opportunity to work with Team Leaders

Weak..Strong
Comments: